PLANT PATHOLOGY

A RECORD OF CURRENT WORK ON PLANT DISEASES AND PESTS

Published quarterly for the
Ministry of Agriculture, Fisheries and Food
Plant Pathology Laboratory
Harpenden, Herts

VOLUME 9, No. 4
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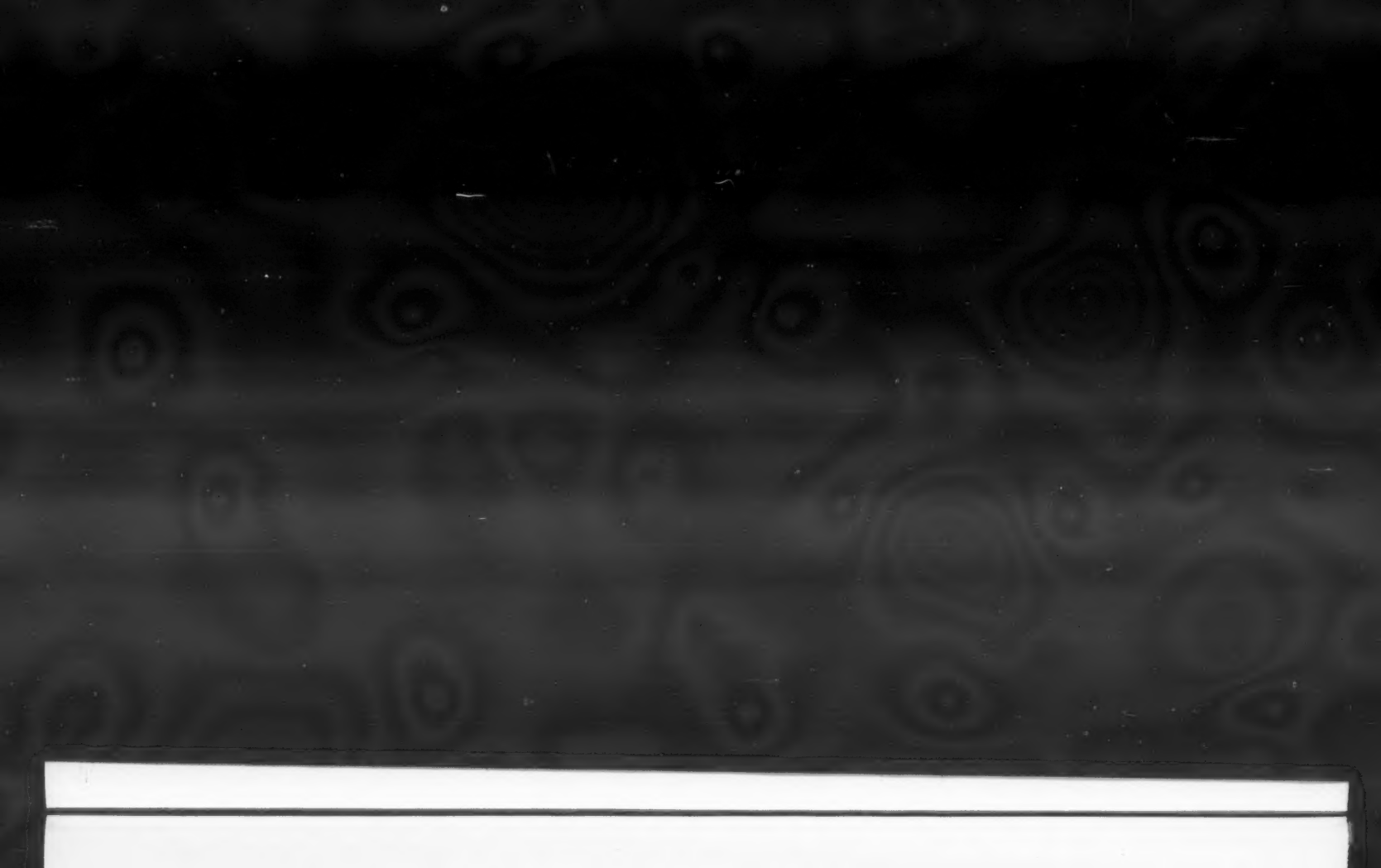

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EFFECT OF PREVIOUS CROPPING ON EYESPOT AND TAKE-ALL IN FOUR VARIETIES OF WINTER WHEAT

by D. A. DOLING *and* C. C. V. BATTS*

National Institute of Agricultural Botany, Cambridge

FOLLOWING the occurrence of a severe outbreak of eyespot, *Cercosporella herpotrichoides* Fron. in the winter wheat variety trials at the Norfolk Agricultural Station in 1950, a combined varietal and previous cropping trial was conducted at Sprowston in 1951–53 as part of the research and advisory programme of the station (Batts and Fiddian, 1955). The trial has been continued during 1954–57.

Four blocks, each of one acre, all of which were under winter wheat in 1953, were cropped as follows in the subsequent three years. The blocks were in the order IV, II, I, III, in the field.

	I	II	III	IV
1954	Winter wheat	Spring wheat	Spring oats	Peas
1955	Winter wheat	Peas	Sugar beet	Sugar beet
1956	Winter wheat	Spring wheat	Spring oats	Potatoes

Block I was divided into five plots and sown with four varieties of winter wheat each year, and all blocks were sown with these same varieties in 1957. The varieties Cappelle Desprez, Hybrid 46 and Juliana were sown at the rate of 2½ bushels, and Bersee at 2½ and 1½ bushels per acre. The plots were sown in the same order in each year and in each block, using a sixteen-coulter drill, the third coulter from each end being blocked to give a ten-row harvest plot.

All the crops received the normal cultural treatments of the farm. The manurial treatments (per acre) were: winter wheat, 3 cwt of an NPK (10 : 10 : 15) compound fertilizer in the seedbed and 2 cwt Nitro-Chalk as a top dressing; spring wheat and spring oats, 5 cwt of an NPK (10 : 10 : 15) compound; peas, 5 cwt NPK (9 : 6 : 15) compound; potatoes, 10 cwt NPK (10 : 10 : 15) compound and sugar beet, 10 cwt NPK (10 : 10 : 15) compound fertilizer and 4 cwt of Kainit.

Before harvesting, each plot was divided into two sub-plots, 60 yards long, from both of which five samples of straws were taken. Each sample consisted of the plants growing in one-foot lengths of two adjacent rows, in positions taken at random. The straws were examined, and a record made of those which were free from disease and those infected with eyespot, sharp eyespot and take-all. Eyespot-infected straws were classified into those with slight and severe lesions; the categories being similar to those used by Glynne and Salt at Rothamsted. The plots were harvested by combine harvester, and the yield of grain determined with correction to 14 per cent moisture content. The four outside buffer rows of each plot were discarded so that the area harvested was 1/48th of an acre.

Very little lodging occurred in any of the plots, so that losses due to this cause were negligible. Take-all, *Ophiobolus graminis* (Sacc.) Sacc., was never severe enough to produce typical take-all patches, but gave rise to scattered whiteheads. Harvest samples revealed the presence of the fungus on the roots and, less often, on the base of some of the straws. Sharp eyespot, *Corticium solani* (Prill. & Delacr.) Bourd. & Galz., was prevalent over the whole area, and fluctuations from year to year were recorded. It is unlikely that this disease materially

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influenced the yield as the lesions are generally superficial. Only eyespot, which produced severe lesions on some of the straws, varied in intensity according to variety, seed rate and previous cropping, sufficiently to influence yield.

INCIDENCE OF DISEASE IN BLOCK I UNDER CONTINUOUS WINTER WHEAT

In the 1953 wheat crop, which followed two barley crops, (Table 1) the number of straws infected with eyespot was high (84·0 per cent), and with take-all low (0·4 per cent). In subsequent years, the total eyespot fluctuated between this and 51 per cent, while take-all increased in 1954 to 6·9 per cent, fell the following year to 0·2 per cent and then rose to 11·1 per cent by 1957. Cappelle Desprez showed the lowest incidence of severe eyespot and the highest yield of each variety in each year.

TABLE 1

Data for Block I with Continuous Wheat, 1953–57

	Variety	Year				
		1953	*1954*	*1955*	*1956*	*1957*
Straws/foot ..	Bersee*	12·1	10·8	13·4	21·1	15·1
	Bersee	14·1	5·7	17·8	20·4	17·4
	Hybrid 46	12·9	14·4	17·6	20·0	14·2
	Cappelle Desprez ..	10·4	12·8	18·4	22·5	20·9
	Juliana	16·9	14·8	16·9	19·4	18·0
	Mean	13·3	11·7	16·8	20·7	17·1
Eyespot	Bersee*	82·7	50·0	34·1	44·7	75·2
	Bersee	87·5	58·2	63·3	53·5	71·5
	Hybrid 46	80·6	84·1	79·3	54·0	66·6
	Cappelle Desprez ..	83·6	59·8	67·0	43·8	52·7
	Juliana	85·5	73·3	71·4	59·7	79·1
	Mean	84·0	65·1	63·0	51·1	69·0
Severe eyespot ..	Bersee*	23·0	4·6	2·2	18·2	40·1
	Bersee	43·6	2·6	5·0	19·8	55·7
	Hybrid 46	29·0	20·1	7·7	23·0	29·6
	Cappelle Desprez ..	16·8	1·2	2·9	11·7	26·5
	Juliana	74·9	9·5	8·3	17·5	40·0
	Mean	37·5	7·6	5·2	18·0	38·4
Sharp eyespot ..	Bersee*	13·5	65·1	11·1	34·1	10·6
	Bersee	10·2	30·8	7·8	24·6	7·5
	Hybrid 46	13·5	19·0	2·8	35·0	8·8
	Cappelle Desprez ..	11·0	31·5	6·3	38·3	19·6
	Juliana	13·2	27·5	3·0	23·9	7·8
	Mean	12·3	34·8	6·2	29·2	10·9
Take-all	Bersee*	—	11·1	0·0	12·8	7·0
	Bersee	—	4·3	1·1	8·4	15·5
	Hybrid 46	—	1·4	0·0	1·5	8·5
	Cappelle Desprez ..	—	13·6	0·0	6·4	9·8
	Juliana	—	4·4	0·0	7·9	9·2
	Mean	0·4	6·9	0·2	7·4	10·0
Yield (cwt/acre) ..	Bersee*	28·5	6·9	37·6	17·1	24·7
	Bersee	27·8	7·9	39·6	17·2	19·0
	Hybrid 46	29·4	12·6	41·0	15·6	22·5
	Cappelle Desprez ..	34·0	17·2	45·9	23·8	24·6
	Juliana	18·3	12·4	31·3	10·4	19·3
	Mean	27·6	11·4	39·1	16·8	22·0

* Seed rate 1½ bushels per acre; all other seed rates 2½ bushels.

In years of little severe eyespot the plots of Bersee sown at each seed rate had similar numbers of infected straws, but in 1953 and 1957 when the disease was prevalent, fewer straws were infected in the plots sown at the lower seed rate. Only in 1957, the year when eyespot was most prevalent, did the seed rate appreciably influence the yield, when the plot at the lower seed rate had 39·5 per cent and the plot at the higher seed rate had 55·5 per cent severely infected straws, the yields being 24·7 and 19·0 cwt per acre respectively.

INCIDENCE OF DISEASE IN 1957

TABLE 2

Data for 1957, Showing Effects of Cropping in Previous Three Years

	Variety	1954: Wheat 1955: Wheat 1956: Wheat I	Sp. Wheat Peas Sp. Wheat II	Sp. Oats S. Beet Sp. Oats III	Peas S. Beet Potatoes IV	Mean I–IV
Straws/foot ..	Bersee*	15·1	17·3	19·7	20·0	18·0
	Bersee	17·4	18·5	19·4	23·0	19·6
	Hybrid 46	14·2	16·7	19·6	20·8	17·8
	Cappelle Desprez ..	20·9	18·8	21·4	26·6	21·9
	Juliana	18·0	17·9	18·2	22·5	19·1
	Mean	17·1	17·8	19·7	22·6	19·3
Eyespot	Bersee*	75·2	14·4	18·3	28·1	34·0
	Bersee	71·5	16·0	31·8	32·0	37·8
	Hybrid 46	66·6	40·1	17·9	21·5	36·5
	Cappelle Desprez ..	52·7	14·1	16·6	47·0	32·6
	Juliana	79·1	21·3	21·0	41·9	40·8
	Mean	69·0	21·2	21·1	34·1	36·3
Severe Eyespot ..	Bersee*	40·1	4·0	3·3	11·3	14·7
	Bersee	55·7	4·6	2·6	3·5	16·6
	Hybrid 46	29·6	9·0	1·8	2·9	10·8
	Cappelle Desprez ..	26·5	3·5	1·6	12·2	10·9
	Juliana	40·0	7·0	5·0	11·8	15·9
	Mean	38·4	5·6	2·9	8·3	13·8
Take-all	Bersee*	7·0	19·1	0·0	0·7	6·7
	Bersee	15·5	24·9	0·8	0·0	10·3
	Hybrid 46	8·5	15·0	0·8	0·0	6·1
	Cappelle Desprez ..	9·8	28·2	0·2	0·4	9·7
	Juliana	9·2	23·0	0·0	0·0	8·1
	Mean	10·0	22·0	0·4	0·2	8·2
Sharp Eyespot ..	Bersee*	10·6	18·8	5·1	5·3	10·0
	Bersee	7·5	10·8	23·3	13·5	13·8
	Hybrid 46	8·8	8·7	6·1	2·9	6·6
	Cappelle Desprez ..	19·6	18·9	20·8	23·2	20·6
	Juliana	7·8	19·6	5·5	9·1	10·5
	Mean	10·9	15·4	12·2	10·8	12·3
Yield (cwt/acre) ..	Bersee*	24·7	29·8	33·9	36·7	31·3
	Bersee	19·0	29·9	35·8	36·1	30·2
	Hybrid 46	22·5	31·1	34·8	44·1	33·1
	Cappelle Desprez ..	24·6	30·8	35·3	42·7	33·4
	Juliana	19·3	26·0	27·9	35·3	27·1
	Mean	22·0	29·5	33·5	39·0	31·0

* Seed rate 1½ bushels per acre; all other seed rates 2½ bushels.

In the crop following spring wheat (Block II, Table 2) the incidence of eyespot was less than after continuous winter wheat (Block I), and the level of severe eyespot was too low to have much effect on the yield. This lower incidence of eyespot was associated with a higher incidence of take-all, but their combined effect on depressing the yield was less than that of eyespot alone in Block I.

Neither disease was severe enough to cause appreciable damage to the crop following spring oats (Block III), and so the yield of each variety was higher than either Blocks I or II.

Residues from the heavy fertilizer dressings on the potato and sugar beet crops in Block IV produced a high fertility which, together with the low incidence of disease, gave rise to a high straw density in the winter wheat plots. This high straw density could account for the slight increase in eyespot over that for Block III, but the amount of severe eyespot infection was still too low to have appreciably influenced the yield.

CONCLUSIONS

Yields of all varieties tended to decrease as the percentage of straws infected with severe eyespot increased. Cappelle Desprez, with the highest straw density, had rather less severe eyespot than the other varieties, and produced the highest yields. Some of this difference in yield is attributable to the fact that it is a high yielding variety which in disease-free years yields more than the others, but the largest difference occurred when the severe eyespot infection was high (Block I). This confirms its ability to yield well despite high incidence of eyespot (Batts and Fiddian, 1955).

A reduction in the seed rate of one bushel/acre slightly reduced the straw density in most of the Bersee plots, but only in Block I, where the incidence of severe eyespot was high, did this treatment produce a marked difference in intensity. At the lower seed rate the level of severe eyespot was less and the yield more than at the high seed rate, as previously found by Glynne (1951) and Salt (1953).

The previous cropping of the blocks noticeably influenced the yields of the 1957 wheat crops. Where this produced high fertility the yield was increased, but where it encouraged high incidence of eyespot or take-all a reduction, sometimes severe, resulted.

SUMMARY

Records of the occurrence of eyespot and take-all on four winter wheat varieties were made during 1954–57. An examination of the influence of each of these, and that of four previous cropping sequences, on the yield of grain has shown that severe eyespot is of considerable importance, particularly when winter wheat crops are grown successively. Under such conditions Cappelle Desprez was the least affected variety and produced the highest yield.

Thanks are due to the Director and Executive Committee of the Norfolk Agricultural Station for facilities for carrying out this work in their trials; to Dr. Mary Glynne for advice in preparing the manuscript; and to our colleagues on the staff of the N.I.A.B. who did the field work and assisted in the examination of samples.

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LOSSES OF DRY HARVESTING PEAS DUE TO PEA MOTH IN EAST ANGLIA AND THE ECONOMICS OF CONTROL MEASURES

by T. J. LEGOWSKI *and* H. J. GOULD

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IN 1959 a survey was made of pea moth damage on dry harvesting peas, mainly Marrowfats (approximately 84 per cent of the dry pea acreage consists of Marrowfats) in an important pea growing area of East Anglia comprising the counties of Essex, the Isle of Ely and the Holland Division of Lincolnshire. A random sample of growers of dry peas compiled on the basis of the 1958 June Returns was kindly supplied by the Ministry's Statistical Branch. The sample was stratified by county and by the acreage of dry peas per holding into: less than 10 acres, 10–30 acres and more than 30 acres. There were 40 growers in Essex, 40 in the Isle of Ely and 30 in Holland, Lincs, representing approximately 8 per cent of the holdings and of the dry pea acreage in these three counties in 1958. The three acreage groups were represented in the ratio 1·0:1·2:1·1. As not all of these growers had peas in 1959 (the dry pea acreage fell by about 18 per cent in that year), some replacements—mostly for the growers in the lowest acreage group—had to be taken from a more comprehensive list also supplied by the Ministry. Table 1 gives the details of the final sample surveyed.

TABLE 1

Details of the Sample of Fields Surveyed in 1959

Acreage of Peas per Holding	No. of Fields Visited			Total	No. Fields Sprayed	Actual Ratio of Dry Pea Acreage (1958)
	Essex	Isle of Ely	Holland Lincs			
<10..	8	1	5	14	4	1
10–30	18	17	11	46	20	2·1
+30..	15	18	18	51	23	2·3
Total fields visited ..	41	36	34	111		
No. fields sprayed	19	18	10		47	

On each field the percentage of pods attacked, and the size and number of larvae found, were recorded. Where fields had been sprayed, the date of spraying, the number of sprays applied, and method of application, were also recorded. Sprays had been applied on 47 of the fields visited, and 64 were untreated. Similar, though less detailed, surveys were made in 1957 and 1958, when 68 and 37 fields of dry harvesting peas respectively were examined as part of the Advisory Entomologists' co-operative work on pea pests. Full details of the surveys and of the methods used will be published in due course.

An analysis carried out on the percentage pod attack on unsprayed fields, and on the acreage of peas per holding, suggests that the average attack was somewhat higher in the lowest acreage group (32·9 $\pm$ 7·4 per cent) than in the

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other two groups (25·0 ± 3·3 and 23·0 ± 3·2 per cent), although these differences were not significant. As a further check, in case this reflected an association between the size of field and the degree of attack, results from 1957 and 1958 surveys when field size was recorded were also analysed but there was no evidence of any correlation. Therefore for the purpose of estimating the total losses the differences in the attack between the three acreage size groups have been ignored—especially in view of the relative importance of the two larger groups—and equal weight has been given to the information from each sampled field. Before attempting to assess the financial and the equivalent acreage losses due to pea moth in the three counties and the economics of control measures it was necessary to establish the proportion of peas damaged by pea moth and the contract prices for dry peas.

THE PROPORTION OF PEAS DAMAGED BY PEA MOTH

This depends on four factors: the percentage of pods infested; the number of larvae per pod; the number of peas damaged by one larva; and the number of peas per pod.

The percentage pod infestation based on samples of 100 pods was known for each field surveyed; the average number of larvae per pod was also obtained from samples of 100 pods from each of the 64 unsprayed fields inspected in 1959, and is shown in Table 2; there was only one sprayed field with a pod attack of over 40 per cent. On the remainder of the sprayed fields the average larval density was 1·1 per pod.

TABLE 2

Number of Larvae per Infested Pod at Different Levels of Attack

Pod Attack *per cent*	Number of Fields	Number of Larvae per Infested Pod
1–40	54	1·1 ± 0·012
41–50	6	1·2 ± 0·04
Over 50 ..	4	1·4 ± 0·12

The number of peas damaged by one larva depends to some extent on the size the larva has reached by the time the peas have matured. Two figures were obtained in the 1959 survey: 1·9 and 1·4. The first figure was based on an examination of 100 pods, each with one exit hole indicating attack by one fully fed larva which had left the pod. This, therefore, was the maximum likely damage due to one larva. The second figure was based on an examination of 240 mature pods, each also attacked by a single larva but only 20 per cent of these larvae had finished feeding. This sample was taken at the time the peas were being cut and more damage would have occurred before threshing. On the other hand a proportion of larvae would almost certainly fail to mature and therefore the average number of peas damaged by one larva would be between 1·9 and 1·4. A figure of 1·7 was taken as a fair estimate and is used in the calculations which follow. The average number of peas per pod, 4·2 ± 0·3, was obtained from examination of 1,000 pods collected from several fields.

With the figures obtained for each of the four relevant factors it is possible to calculate the percentage of damaged peas for each level of pod attack, and the relationship is shown in Fig. 1.

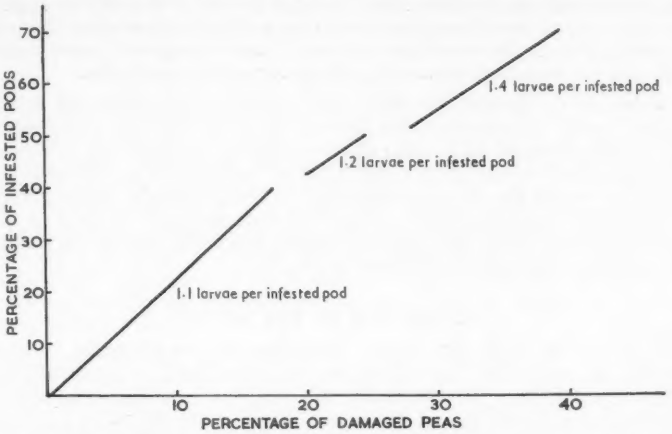

Fig. 1. Relationship between percentage of infested pods and percentage of peas damaged, assuming a mean of 1·7 peas damaged by one larva, and a mean of 4·2 peas per pod.

THE CONTRACT PRICE FOR DRY PEAS

The 1958 and 1959 prices paid to the growers were obtained from two leading canning firms and from a large firm of agricultural merchants. The prices depended on the weight of "wastage", i.e., of peas stained, damaged mechanically or damaged by pea moth, which would have to be removed before processing. The top price of 61*s.* to 63*s.* per cwt was paid for peas with little or no wastage. Thereafter it was reduced by 9*d.* to 1*s.* for each 1 per cent of wastage until a level of about 34 per cent was reached after which the price remained at 30*s.* per cwt. Peas with a higher wastage need not have been accepted by the contractor. Knowing these prices, it was possible to calculate the average price per cwt paid to the grower according to the level of wastage (Fig. 2).

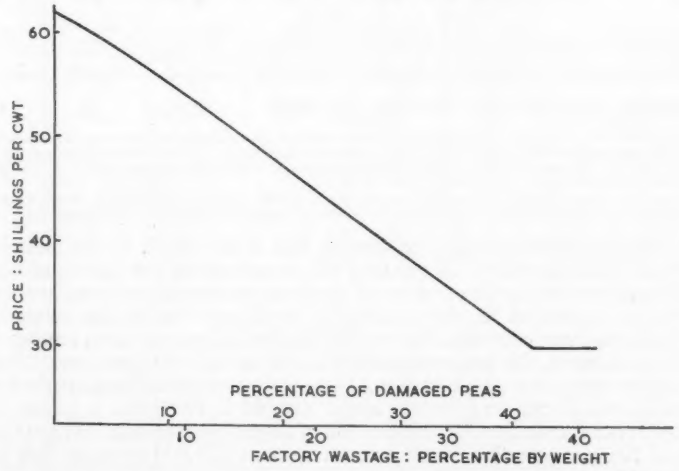

Fig. 2. Approximate contract prices of dry peas in 1958–59 according to amount of wastage.

The prices paid by the three firms diverged at very low and very high levels of wastage, i.e., at less than about 8 per cent and more than about 50 per cent pod attack. For the intermediate and more usual range the prices were very similar and the error introduced by taking a mean is negligible.

To calculate the financial losses it was necessary to convert our figures for the percentage of damaged peas which were based on numbers into appropriate levels of wastage based on weight; this was done by weighing the same number of damaged and sound peas from 12 lots, each from a different grower, supplied by one of the canning factories. Four sub-samples each of 100 peas were weighed from each lot. On average the damaged peas weighed 13 $\pm$ 1·04 per cent less than sound peas, and this figure has been used as the conversion factor to obtain the scale for wastage in Fig. 2.

LOSSES DUE TO PEA MOTH

With the results from the survey, the losses can be estimated in terms of money and the equivalent loss of acreage due to pea moth in the three counties. Separate estimates have been made for the unsprayed and the sprayed acreage. The method of calculation and the results for 1959 are shown in Table 3.

TABLE 3

Estimate of Losses in 1959

	Unsprayed fields			Sprayed fields		
	Essex	Isle of Ely	Holland, Lincs	Essex	Isle of Ely	Holland, Lincs
Acreage of dry peas*	4,080	2,220	7,800	3,480	2,210	3,190
Mean pod attack per cent	30·7±4·9	20·4±2·3	24·5±2·5	17·5±2·4	9·3±1·2	11·8±1·9
Mean peas damaged per cent	13·7	9·1	10·9	7·8	4·0	5·2
Mean wastage per cent	11·9	7·9	9·5	6·8	3·5	4·5
Loss per acre† ..	165*s.* 9*d.*	137*s.* 6*d.*	180*s.*	89*s.* 3*d.*	55*s.*	78*s.*
Total loss (approx.)	£34,000	£15,000	£70,000	£15,500	£6,000	£12,500
Loss in acres ..	559	202	850	271	88	166

* The total acreages of dry peas in Essex, the Isle of Ely and Holland, Lincs in 1959 were respectively, 7,560, 4,430 and 10,990. The estimated percentages of the fields sprayed in the three counties were 46 $\pm$ 7·8, 50 $\pm$ 8·3 and 29 $\pm$ 8·1, respectively.

† Based on average yields of 17 cwt per acre for Essex, 22 cwt for the Isle of Ely and 24 cwt for Holland, Lincs. (Provisional yield figures for 1959 supplied by the Ministry's Statistical Branch at Guildford.)

In 1959 therefore the total loss directly due to pea moth on dry peas in the three counties (comprising 70 per cent of the acreage of dry harvested peas in East Anglia and about 40 per cent of the total acreage of dry peas in England and Wales) amounted to about £150,000, or 10 per cent of the value of the crop in those three counties. Converting the loss of peas in each county to its equivalent in acres, the loss amounted to 2,140 acres, or 9·3 per cent of the dry pea acreage taken out of production. These estimates do not include the loss of weight (about 13 per cent—worth about £14,000 in 1959) due to holing of the peas by larvae nor do they include the cost of controlling the pest. Even at the low figure of 70*s.* per acre this would amount to some £31,000 spent in 1959 in the three counties.

Using the 1957 and 1958 survey results, an attempt has also been made to obtain some estimate of losses in these two years. This estimate is probably less accurate as fewer fields were surveyed, and the work covered several pea pests and had to begin before much pea moth damage was present. Using, however, the results from fields visited near harvest, and the information on the progress of infestation from fields visited early and late, the average levels of pod attack in the three counties were estimated at approximately 14 per cent and 21 per cent on unsprayed fields, and 14 per cent and 13 per cent on the sprayed fields in 1957 and 1958 respectively. The acreage of dry peas was greater: 27,000 in 1957 and 28,000 in 1958. On the basis of these figures, in 1957 the losses were estimated at about £85,000, equivalent to some 1,700 acres or just over 6 per cent of dry pea acreage lost to production; and in 1958 at about £119,000, equivalent to 2,500 acres or 9 per cent of the dry pea acreage. They do not include the cost of spraying or the loss of weight of peas due to the holes made by larvae and are based on 14 cwt per acre as the average yield.

The estimates for 1957 and 1958 are based on 1959 figures for number of peas damaged by one larva and number of peas per pod. An independent estimate of number of larvae per infested pod for different levels of attack was obtained in 1958, and this agreed with the figures for 1959. Some figures for the number of peas damaged by one larva were obtained by Wright, Geering and Dunn (1951) and they ranged from 1·2 and 1·6 with 11 per cent and 36 per cent of the larvae fully fed, to 2·0 and 2·3 with the majority of larvae mature. In this respect therefore, our calculations may slightly underestimate the losses in 1957 and 1958.

THE ECONOMICS OF SPRAYING

Table 4 shows the percentage of damaged peas and the equivalent wastage calculated for different levels of pod attack and the equivalent loss of money per cwt. It also shows the likely gain per cwt and per acre for three different yield levels if the attack was reduced by 50 per cent and 70 per cent respectively. The costs of the control measures have not been taken into consideration. These estimates are based on data shown in Table 1 and in the text beneath it; they are subject to a standard error of about 10 to 15 per cent.

TABLE 4

Monetary Loss and Gain (in shillings) at Different Levels of Attack and Control

Pod Attack *per cent*	Damaged Peas *per cent*	Wastage *per cent*	Loss *per cwt*	Gain* with 50 per cent Control				Gain* with 70 per cent Control			
				per cwt	*per acre with yields of*			*per cwt*	*per acre with yields of*		
					15 *cwt/a*	23 *cwt/a*	30 *cwt/a*		15 *cwt/a*	23 *cwt/a*	30 *cwt/a*
				s.	*s.*	*s.*	*s.*	*s.*	*s.*	*s.*	*s.*
10	4·5	3·9	3	1·5	23	35	45	2·0	30	46	60
20	8·9	7·7	6	3·5	53	81	105	5·0	75	115	150
30	13·4	11·7	10	5·0	75	115	150	7·0	105	161	210
40	17·8	15·5	13	6·6	98	150	195	9·5	143	219	285
50	24·3	21·1	18	10·0	150	230	300	13·0	195	299	390
60	34·0	29·6	26	16·0	240	368	480	20·5	308	472	615
70	39·7	34·5	30	18·5	278	426	555	22·5	338	518	675

* Excluding the cost of control measures.

The cost of spraying varies: a single application by the grower will cost about 37*s.* to 43*s.* per acre (25*s.* to 28*s.* for materials and 12*s.* to 15*s.* for labour and machinery); if done by a contractor it will cost about 60*s.* to 75*s.* for ground spraying and 65*s.* to 85*s.* for aerial spraying, including the cost of materials. An allowance must also be made for damage to the crop by the tractor wheels and in the absence of any precise information a 2 to 3 per cent loss of crop, worth approximately 30*s.* per acre for fields with a yield of 15–23 cwt per acre and 45*s.* for those with 30 cwt per acre, can be taken as a conservative estimate. Before comparing the cost of spraying with the benefit likely to be obtained by the grower, we must also consider the efficiency of the treatment.

In our 1958 plot trials (Gould and Legowski, 1959) two or three sprays reduced pea moth damage by 60–70 per cent. Similar results were obtained in two further plot experiments in 1959 with two sprays applied by hand-lance, the first timed by the presence of eggs on the plants. A comparison of the sprayed and unsprayed fields visited in the 1957–1959 surveys, suggested that only a 50 per cent control had been achieved by growers, mostly with a single spray in 1959, and an even lower control in 1957 and 1958, when timing was often at fault.

It can therefore be assumed that in 1959 a single spray was unlikely to give the grower more than a 50 per cent control, and that two sprays, the first one often badly timed, would reduce the infestation at most by 70 per cent. Using these figures the levels of pod attack at which spraying would probably just about pay for itself can be estimated (Table 5).

TABLE 5

Costs (in shillings) of Spraying and Minimum Attack Necessary to Recover Costs at Different Yield Levels

	Yield per acre *cwt*	One spray (50 per cent Control)			Two Sprays (70 per cent Control)		
		By Grower	By Contractor		By Grower	By Contractor	
			Air	Ground		Air	Ground
Average cost per acre (incl. damage to crop by wheels) *shillings*	15–23	70	70	95	110	140	150
	30	85	70	110	125	140	165
Cost per cwt (*To nearest shilling*)	15	5	5	6	7	9	10
	23	3	3	4	5	6	7
	30	3	2	4	4	5	6
Minimum percentage pod attack necessary to recover costs	15	28	28	37	31	41	
	23	18	18	23	21	28	
	30	17	15	22	18	21	

As might be expected, improvement in the control would reduce the minimum level of pod attack at which spraying would pay for itself. Thus, with a near perfect control of 90 per cent with two sprays, taking again the yields of 15 cwt, 23 cwt and 30 cwt per acre, the appropriate levels of pod attack would be about 25, 16 and 14 per cent if the grower did the spraying, and 33, 23 and 20 per cent if it were done by contractor.

It is worth noting that the data in Tables 4 and 5 would not be greatly affected by a change in prices for peas as long as the difference in prices according to the different levels of wastage remained the same.

ECONOMICS OF PEA MOTH CONTROL IN EAST ANGLIA IN 1959

Accepting on the evidence presented earlier that a single spray reduced the potential infestation by 50 per cent, and that two sprays gave a 70 per cent control, it is possible to estimate the likely attack on the 47 sprayed fields inspected in the 1959 survey if no sprays had been applied. Knowing this and the methods of control used, a balance sheet can be prepared for each treated field separately and a statement of the net profit or loss for the control of pea moth on all treated fields bulked together. Thus on 22 (47 per cent) of the 47 sprayed fields the costs were greater than the probable gain, while on 25 fields (53 per cent) the gain probably outweighed the costs. Bulking all treated fields together, the estimated average cost of spraying (including damage to crop) was 3*s.* 10*d.* per cwt and the average probable gain due to reduction of pea moth damage 5*s.* 7*d.* per cwt, showing a net gain of 1*s.* 9*d.* per cwt.

Similarly, one can estimate how many of the 64 untreated fields would have been worth spraying. Of these, 29 had less than 20 per cent attack; 25 had between 21 and 40 per cent attack, and 10 had more than 40 per cent attack. The average pod infestation over all fields was 25 per cent. The results can be arranged according to the type of treatment which might have been used, and this is shown in Table 6.

TABLE 6

Estimated Number of Untreated Fields Worth Treating in 1959

No. of Untreated Fields Inspected	With One Spray			With Two Sprays	
	By the Grower	By the Contractor		By the Grower	By the Contractor Air or ground
		Air	Ground		
64	43	43	28	32	19

This shows that in 1959 spraying twice by the contractor would not have been economically justified on the majority of the 64 unsprayed fields examined. There would have been rather more justification for two sprays applied by the grower and much more for a single spray applied either by the contractor from the air, or by the grower. The reason is the proportionately small increase in control obtained compared with the cost of the additional treatment.

CONCLUSIONS

Pea moth is quite an important pest, at least in East Anglia. The figures show that with the present-day prices for peas, the costs and the efficiency of spraying, the economics of control measures are not as favourable to the grower as might have been thought, especially in areas or years of average or low yields. The economics appear more favourable on fields with higher yields, but even then pod infestations of 25 per cent or more are necessary to justify two sprays. Such levels of attack are not very common.

If, with careful timing, a 50 per cent control with one spray could be relied on, and if a 70 per cent control is all a grower could expect with two sprays, there may be more justification for spraying only once. A single spray timed correctly would give a measure of insurance against heavy losses in a year of unusually heavy attack, and would have a better chance to show profit when the attack was light. It is possible however, that the 50 per cent control obtained

by growers, mostly with a single spray, in 1959, was obtained only because the season was unusually short; in a longer season the control may not reach that level. In such a season two sprays may be necessary to protect the crop over the longer susceptible period. Whatever control measures are taken, more often than not the margin of profit is likely to be small, and this emphasises the importance of making the sprays as efficient as possible. Since correct timing is probably the most important single factor affecting the efficiency of sprays, the results stress the need for correctly advising the grower when to spray. They also add weight to the need for work on a long range project of forecasting the severity of attacks or at least defining areas where pea moth is a recurrent problem and is likely to be serious.

SUMMARY

Following surveys of pea moth damage on dry harvesting peas in 1957–59 in the Eastern Region, figures are given to show the loss of peas and the loss of money to the grower at different levels of pod attack. It is estimated that in each of the last three years the annual pea moth damage on dry peas in the three counties surveyed was of the order of £100,000, excluding the cost of spraying, and this would be equivalent to the total production from some 2,000 acres of dry peas. By comparing the costs of spraying with the likely gain according to the efficiency of the treatment, it was possible to show the approximate levels of pod attack at which spraying would pay for itself. In 1959 spraying probably paid for itself on 53 per cent of the treated fields inspected.

We are indebted to Miss E. C. Mason for providing us with the survey results for Lincs (Holland) and to Dr. H. C. Gough and Mr. E. Brown for many valuable suggestions. We also wish to thank Mr. K. G. Gardner, of Crosse and Blackwell, Ltd., Messrs. Batchelors Foods, Ltd., and Eastern Counties Farmers, Ltd., for their kind co-operation.

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DETECTION OF LEAF ROLL IN POTATO TUBERS

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SOME potato plants show no external symptoms during the year in which they become infected with virus. As their tubers will give diseased plants in the next year, a method for deciding whether or not seed tubers are infected would be very useful. Two methods were tested. First, a staining technique was tried, based on the abnormal formation of callose in the phloem sieve tubes of tubers with leaf roll virus. Second, newly harvested tubers were treated chemically to break their dormancy, and they were grown on the south coast of England during the autumn.

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CALLOSE STAINING

Several publications in recent years have described techniques for staining the callose formed in the phloem of leaf roll-infected tubers or sprouts (Baericke, 1955; Heilmann, 1955; Moericke, 1955; Sardiña, Orad and San Roman, 1958). We examined only unsprouted tubers lifted after the haulms died, but other workers have found the method works with sprouts. Of the several stains for callose, we used only "resorcin blue".

Tubers were lifted at maturity in September and tested at intervals between October and February. The "heel" end of each tuber was cut off and hand sections were cut through two or more regions of the vascular tissue. Ten sections from each tuber were stained with 1·0 per cent resorcin blue in 0·1 per cent ammonia, rinsed in water, mounted on a glass slide, and examined under a low-power microscope. Each section was classified according to the amount of callose stained. Each tuber was numbered with waterproof ink, stored until the spring, and then grown in the field. The label was still recognisable on the parent tuber in June when plants were showing diagnosable symptoms, and this enabled the laboratory diagnoses to be compared with those made in the field.

Tests were made during three years, in 1956 with a stock of variety King Edward, and in 1957 with one of Majestic. Both included tubers infected with leaf roll or Y viruses, and included both primary (current season) and secondary infections. In 1958 more Majestic tubers were tested, but these were either healthy or primarily infected with leaf roll. Tubers secondarily infected with leaf roll, either of King Edward or of Kerr's Pink, were also tested.

The results were difficult to grade, because of variability in the staining of the sections. For example, some sections from a tuber often stained strongly whereas others did not stain; in other tubers all sections stained equally. A tuber was graded as "infected" if most of the sections showed callose along the end plates of many sieve tubes (Plate III, 2), or if some elongated "plugs" of callose were found in half or more of the sections. Small areas with callose formation were disregarded and a general impression of each section was obtained by using low magnification. These results were compared with those obtained visually in the field. The assumption was made that plants infected showed symptoms in the field, as this is the usual method of assessing virus disease incidence.

The results (see Table) from the staining tests never agreed completely with those in the field; unstained sections were obtained from tubers that produced infected plants in the field, and stained sections from tubers that gave apparently healthy plants. When the individual history of each tuber was unknown 82 per cent of the diagnoses based on sectioned material were correct, but although unstained sections usually indicated a healthy plant (87 per cent correct diagnoses), stained sections did not as accurately indicate leaf roll-infected ones (61 per cent correct diagnoses). Callose formation may occur from other causes, but the tubers in these experiments were apparently unharmed. These factors overestimate the incidence of leaf roll and it is more important not to underestimate, but 9 per cent of the plants that showed leaf roll grew from unstained tubers. Sections from tubers produced by plants infected with leaf roll in the current season stained no less heavily than those from plants infected in the previous season, and the two types could not be distinguished. Virus Y-infected tubers were not stained.

When 54 King Edward seed tubers produced by leaf roll-infected plants (secondary infections) were tested, 44 were correctly diagnosed. Similarly 9 of 10 secondarily-infected Kerr's Pink tubers were diagnosed.

Leaf Roll-Infected Tubers as Shown by the Staining Test Compared with Infected Plants seen in the Field

Variety and year		No. showing Leaf Roll in the field		No. without Leaf Roll in the field	
		+ by stain test	− by stain test	+ by stain test	− by stain test
1956	King Edward ..	23	12	17	192
1957	Majestic	19	16	34	131
	Kerr's Pink ..	9	1	0	0
1958	Majestic	20	11	3	44
	King Edward ..	42	8	2	2

DORMANCY BREAKING AND AUTUMN PLANTING OF TUBERS

Potato tubers, some of which were infected with virus, were lifted in mid-August 1955 and immediately treated with "Rindite" (Denny, 1945) to break their dormancy. At the end of August they were planted in the open or under an unheated Dutch light structure at Efford Experimental Horticulture Station, Lymington, Hants. About half the plants emerged by mid-October, but many tubers rotted. Rugose mosaic was diagnosed in some plants under glass, but frost killed the exposed plants before virus disease symptoms could be recognised, and those under glass were too poor for leaf roll to be diagnosed.

CONCLUSIONS

We consider the staining technique unreliable, although experience would probably decrease the error. As only leaf roll can be identified, and virus Y may spread rapidly in parts of England, the method is only of limited use, although it might be of value in countries where there is no efficient seed certification scheme to reject poor stocks.

The second technique, breaking dormancy and growing samples in a warm region, shows little promise in England due to the danger of frost. Plants grown under glass without additional lighting are too drawn and weak to show unequivocal symptoms.

We wish to thank Mr. P. H. Brown and Mr. G. F. Wheeler of Efford Experimental Horticulture Station for growing our samples with great care, and Mr. R. G. Garrett for technical assistance.

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A NEW SPRING OAT VARIETY RESISTANT TO STEM AND BULB EELWORM

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AN oat variety trial, conducted jointly by the National Institute of Agricultural Botany and the National Agricultural Advisory Service, was inadvertently sited on a field containing a small area infested with *Ditylenchus dipsaci* (Kuhn) Filipjev. Three of the six blocks in this trial were laid down on the infested land, the other three on clean land. Differences in varietal susceptibility were obvious by late June, and plant counts made on July 7 indicated that the new variety (Manod) showed a high degree of eelworm resistance. This was assessed by counting the visibly infested plants in five samples of two adjacent 1 ft runs of row per plot, and confirmed by a yield analysis (see Table).

Yields of Manod and Three Other Oat Varieties on Eelworm-infested and Clean Land in a Trial in Durham, 1959

Oat Variety	Three Blocks with Eelworm present		Three Blocks on Clean land	Difference in Yield	Mean Yield
	Infested Plants *per cent*	Yield* *cwt/acre*	Yield* *cwt/acre*		
Flamande	18·3	18·3	27·4	9·1***	22·8
Manod	0·5	24·6	23·0	−1·6 N.S.	23·8
Civena	13·6	21·6	28·3	6·7***	25·0
Sun II	19·2	19·5	25·8	6·3***	22·6
Least Significant Difference (p = 0·05)		3·5			2·4

* At 85 per cent dry matter.

Although in this trial the yield of Manod was low its mean yield in the N.A.A.S./N.I.A.B. 1959 trials over the country as a whole was 98 per cent that of Sun II, in conformity with the view held by workers at the Welsh Plant Breeding Station that its yielding capacity is in general equal to that of Sun II. The only other eelworm-resistant spring oat, Milford, gave a mean yield of only 84 per cent that of Sun II in the N.A.A.S./N.I.A.B. trials over the period 1952–54 (Beesley and Burrell, 1958). As Manod yields better than Milford, and it has now shown eelworm resistance in North Wales (Davies, 1960) as well as Durham, and as it is also considered resistant to mildew, *Erisyphe graminis* D.C., and crown rust *Puccinia coronata* Corda, it is a valuable addition to the varieties available for use in areas prone to these troubles.

We thank the National Institute of Agricultural Botany for the statistical analysis, and for permission to quote the 1959 results of a joint trial prior to publication.

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SCLEROTINIA SCLEROTIORUM ON PEAS IN KINCARDINESHIRE

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THE growing of peas for processing is a recent development in the area served by the North of Scotland College of Agriculture, although they have been grown for some time in Perthshire and Angus. In July 1957, Sclerotinia stem rot (Plate I) was found in three fields in south Kincardineshire. The characteristic white mycelium developed on the affected plants, and sclerotia, about 0·5–1 cm long, formed on the surface and in the cavity of the stems.

Where the attack was severe, in low-lying areas and in a part of a crop undersown with Italian ryegrass, a third of the plants were killed and the yield of peas was about 13 cwt per acre, compared with 2 tons where infection was light. In one crop, the extent of the attack could not be assessed as there was also a heavy infection with *Botrytis cinerea*.

A search was made for the source of the outbreak. Samples of seed sown in the district, and which may have been used in the affected fields, did not contain sclerotia and did not give rise to mycelium of *Sclerotinia* in germination tests or on agar plates. *S. sclerotiorum*, a destructive fungus in many parts of the north of Scotland, especially on potatoes, is not common in south Kincardineshire and no source of infection was found near the pea fields. Clover rot is rarely recorded in Scotland and is not known in the area: there was no sign of sclerotia or apothecia of *S. trifoliorum* in a neighbouring field where beans were grown in 1956.

When the diseased crops were harvested, sclerotia fell to the ground in large numbers and few were left on the haulm. As a precaution, the plants from the part of the field most severely affected were removed to a rubbish dump; the remainder of the haulm was ensiled. In the following spring, there was no trace of sclerotia on the dump or in a grass field where the silage was fed to cattle.

When the pea fields were ploughed, most of the sclerotia were buried to a depth of four inches. In the severely affected area, then under a barley crop, a few remaining near the surface of the soil produced apothecia in June 1958. By early July, the disease was present in the nearest field of peas, two hundred yards away and had spread through the crop for a distance of eight hundred yards from the apothecia. The effect of the disease was again serious, the yield being only 21 cwt per acre.

Outbreaks occurred in three other fields in the neighbourhood. Once again, *B. cinerea* was widespread, so that the initial cause of stem rot could not always be determined.

In June 1959, a few apothecia were found in fields affected in 1958. By July, *Sclerotinia* disease was present on about 5 per cent of plants on all the pea-growing farms in the county, including some which were separated by at least five miles of hill land from the area where the first outbreaks were observed. In the dry summer, the infected stems dried, the plants became straw-coloured and died early. The loss from disease was not apparent as yields were generally high.

IDENTITY OF THE FUNGUS

Sclerotia collected in 1957 were kept in a greenhouse in pots of John Innes potting compost. One germinated to produce an apothecium in September, but the bulk of the apothecia were not formed until the following spring. Inoculation with ascospores and mycelium from cultures resulted in the infection of peas, broad and French beans, lettuce and carrots, though not of beetroot, tomatoes, leeks or red or white clover. An isolate of *S. sclerotiorum* from stored carrots, grown in Aberdeenshire, infected the same range of hosts. On the basis of the time of appearance of the apothecia and the host plants infected, the fungus involved is *S. sclerotiorum.*

CONDITIONS FOR INFECTION

The failure to infect certain plants, such as potato, may have been due to faulty technique and does not necessarily indicate a limited host range for these isolates of the fungus. For inoculation of peas to be successful, it was necessary to injure the plant tissue slightly and to keep the inoculated area damp. Infection took place most readily in the leaf axils. In a dry atmosphere, the infected tissue became dry and papery and growth of mycelium and sclerotia stopped. In very humid conditions, *B. cinerea* grew vigorously on infected tissue and replaced *S. sclerotiorum.*

The fields where the disease has been most serious are subject to wind damage and to hill-fogs. The soils are heavy and retain moisture. Other fungus diseases which require moist conditions, such as eyespot in wheat and blight in potato tubers, give trouble on the same land. In each of the three years 1957–59, there was a period of hill fog in the third week of June. In 1958 and 1959, the apothecia of *S. sclerotiorum* discharged ascospores at this time and it seems likely that infection took place at this period.

The effect of damage was clearly seen in crops sprayed with selective weed-killers, where stems broken by the sprayer and leaf axils scorched by the chemical tended to be infected. In unsprayed crops, it is likely that damage by wind to the long soft stems was sufficient to permit infection. Severe attacks were noted in the varieties Alaska, Gregory's Surprise, Early Canners', Canners' Perfection and Canners' 99, but not in Lincoln, perhaps because its stiffer habit of growth kept the plants erect and dry at the time when the ascospores were discharged.

DISCUSSION

There are apparently no records of *S. sclerotiorum* in pea crops in Britain and although the fungus has been recorded on peas in many countries, there are few reports of serious attack. In Holland (van Poeteren, 1938) sclerotia were found among seed from a pea crop in which the plants had died early, presumably as a result of infection. Crosier (1940) writes of *S. sclerotiorum* as an infrequent associate of pea seed. Infection of pods and stems is reported from New Zealand (Brien, 1932). There are several references to it as the cause of stem rot of peas in the United States (in Montana by Young, 1936; in the southern states by Weimer, 1940; in Idaho by Blodgett, 1946); in Bermuda (Waterston, 1938) and in South America (in Peru by Bazán de Segura, 1952; in Brazil by Neto, 1954; in Argentina by Muntañola, 1955). Muntañola refers to serious outbreaks in 1954, somewhat similar to the Kincardineshire cases. *S. sclerotiorum* causes a disease of garden peas in Morocco (Morocco Plant Protection Service, 1937).

In the north of Scotland, stalk break of potatoes is a serious disease in Lewis, parts of Shetland and Orkney, an area near Invergordon in Ross-shire and Lonmay in north-east Aberdeenshire. *S. sclerotiorum* commonly causes rotting in stored carrots and is reported from time to time on such plants as chrysanthemum, dahlia, forsythia, lettuce, tomato and turnip. The wide distribution of the fungus may constitute a threat to the pea crop, if, as seems likely, weather conditions in summer favour infection.

It would seem advisable, therefore, to avoid growing peas where hill or sea fogs are frequent in summer and where wind damage is excessive. Consideration should be given to methods of weed control which do not involve spraying the growing crop.

Farmers are being urged to plough deeply after an outbreak, in order to bury the sclerotia. Observations on the disease in potatoes and peas have shown that a cereal crop sown on infected land does not provide sufficient cover to prevent the spread of ascospores. There is slight evidence, from observations on outbreaks on potatoes in Ross-shire, that the thicker bottom growth of an undersown cereal crop may check the spread. In practice, neither deep ploughing nor undersowing the crop taken after peas is popular.

SUMMARY

Sclerotinia stem rot was found in July 1957 in three crops of peas (for processing) in south Kincardineshire. Where the attack was severe one third of the plants were killed and the yield was reduced from 40 to 13 cwt per acre. In June 1958, the disease had spread to a crop 200 yards away from that most severely affected in 1957, and by July 1959 it was present on about 5 per cent of the plants in all the pea-growing areas of the county. This is the first record of the disease in Great Britain.

We are indebted to the Scientific Services of the Department of Agriculture and Fisheries for Scotland for the photographs.

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CARROT MOTLEY DWARF VIRUS

by MARION A. WATSON

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A VIRUS disease of carrots that causes serious loss of yield has recently been identified in Great Britain. It is probably the same as one described from Australia by Stubbs (1948, 1952) who named the pathogen, carrot motley dwarf virus. Stubbs identified the virus in California (Stubbs, 1956), but it has not previously been recorded in Great Britain. The vector is the willow-carrot aphid, *Cavariella aegopodii* (Scop.); so far it has not been transmitted by any other species of aphid. *C. aegopodii* is one of the most numerous of spring migrant aphids in Great Britain and often accounts for from 20 to 50 per cent of the total of all aphid species caught on sticky traps in May and June. Our largest recorded catch of winged aphids was 3,363, caught on a sticky trap at Rothamsted during the second week of June, 1957; about 1,600 were *C. aegopodii*. 1957 was an exceptional year; the total catch in one week is not usually more than 1,000 and often fewer than 100. The virus is similar to beet yellows and barley yellow dwarf viruses in its manner of transmission and effect on the host plant. It yellows and dwarfs the foliage, and decreases the growth of the root (Plate IV), probably because it interferes with carbohydrate metabolism in the leaves.

All three viruses belong to the persistant group of aphid transmitted viruses. Once the vectors have become infective they often remain so for several days, and their ability to infect healthy plants usually increases with increasing feeding times on these and on the infected plants from which they acquired virus. The shortest total time needed for both acquisition and transmission is usually longer than the sum of the minimum times required for either separately. For instance, in experiments made at Rothamsted, a few aphids acquired motley dwarf during 7 hours feeding on infected plants and a few infective insects transmitted to healthy plants during ½ hours feeding, but the shortest time for both acquisition and transmission was about 20 hours, and 48 or more hours were needed for maximum efficiency of transmission. Aphids fed for 2 days on infected leaves and then removed to healthy plants every 24 hours without further access to a source of infection remained infective for 8 days, after which the experiment ceased. Stubbs records that they may remain infective for 15 days.

SYMPTOMS

The name given by Stubbs describes motley dwarf very adequately; stunting, and yellow and green mottling of the foliage are the most conspicuous symptoms. In addition, there is usually epinasty of the petioles. Leaves of plants infected as seedlings may curve into a lyre shape, and older petioles are often bent or twisted.

Plants infected young become very stunted and seedlings infected in the glasshouse have their growth rate noticeably slowed within a few days of inoculation and several days before leaf symptoms are recognisable. Later the leaves of infected plants develop a delicate yellow and green mottle (Plate IV, *inset*) and may eventually become completely chlorotic often with red tips to the fronds. Some plants show little yellowing but much reddening of the foliage, particularly when they are infected in the field and also heavily infested with aphids; the aphid feeding seems to suppress the chlorosis and it also causes the young leaves to develop into a parsley-like rosette. Whether this is a result of combined aphid and virus attack, or of aphids alone could not be resolved as all aphid-infested plants that were tested from the field in 1959 were found to contain the virus. Plants deliberately infested in the glasshouse with healthy aphids do not show it, but the insects may not remain on them long enough.

When plants in the field were freed from aphids by insecticide their appearance improved, though they remained yellow, with thin, straggling petioles, and the yield was poor.

Plants infected late in the season are not much smaller than their healthy neighbours and are chiefly conspicuous for their orange-yellow or red foliage. They usually occur in patches resembling those caused by beet yellows virus in a late infected sugar-beet crop. The motley dwarf virus was first collected in England from such a patch in an otherwise exceptionally healthy and well grown crop on a farm near Newmarket, in October 1956. Aphids from these plants transmitted the virus to healthy seedlings in the glasshouse.

INDICATIONS OF EFFECT ON YIELD

An attempt was made at the Woburn Experimental Farm, Bedfordshire, to compare the yields of healthy and infected carrots, in an experiment similar to those used previously with barley yellow dwarf (Watson and Mulligan, 1960) and beet yellows viruses (Watson, 1942). Some plots, protected by aphid-proof cages, were infested with infective aphids, and others were treated with insecticides. With sugar beet and cereal viruses such experiments showed large differences in yield between differently treated plots, but none occurred with the carrots because they were already almost all naturally infected. This was confirmed by testing samples from the crop in the glasshouse. In the field experiment treated and untreated plots alike yielded about $4\frac{1}{2}$ tons per acre, although a yield of about 15 tons per acre could reasonably be expected from a healthy crop. All plants were infested with aphids when observed, and all samples taken contained virus. They were almost free from carrot fly (*Psila rosae*) and there seemed no other explanation of the poor yields than the infestation with aphids and consequent virus infection.

In some years carrot crops at Woburn have apparently failed completely early in the season, and other crops have been sown. One such year was in 1957 in which the largest and earliest recorded migration of aphids took place. By contrast in 1956 when aphids were few and arrived late after the cold winter of 1955–56, carrots at Woburn yielded 16 tons per acre. This follows a pattern made familiar by studies of beet yellows and barley yellow dwarf viruses, and suggests strongly that some of the observed losses and failures were caused by motley dwarf virus, which has probably affected carrots in the area for many years.

The virus has been identified in samples of carrots from seven counties in England, and the disease seems to be of economic importance.

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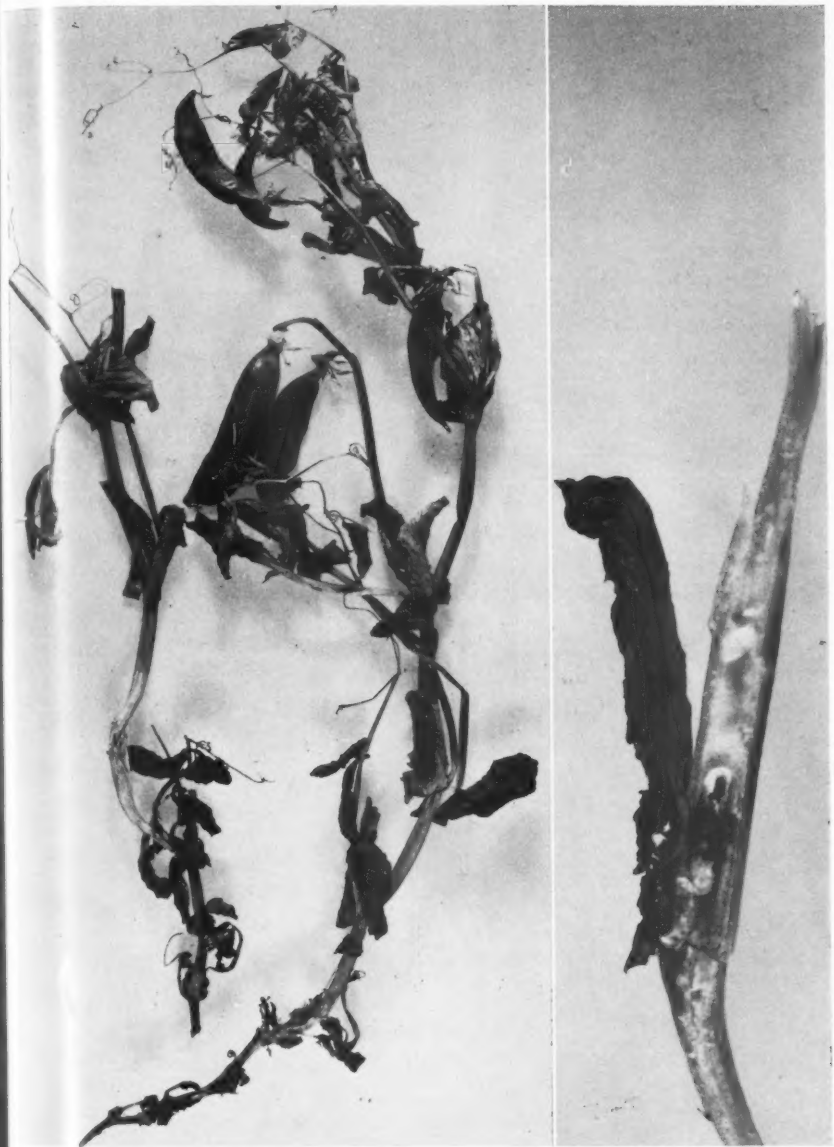


Photo: Scientific Services, East Craigs

Left: Typical appearance of affected haulm; *Right:* Sclerotia developing within stem.

PLATE I

SEED TRANSMISSION OF *DIDYMELLA LYCOPERSICI* (see p. 1 2)

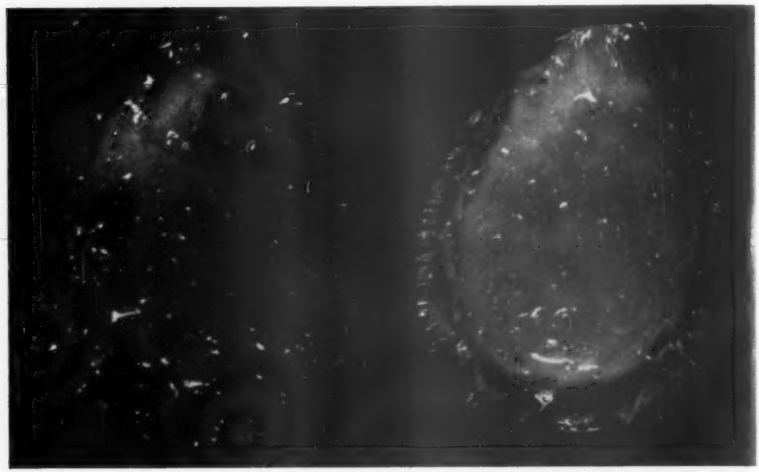


Photo: Scientific Services, East Craigs

1. *Left:* Tomato seed from infected fruit showing pycnidia embedded within seed coat; and *right:* uninfected seed (× 16).

PRESERVATION OF FRUIT CHIP BASKETS (see pp. 150–51)

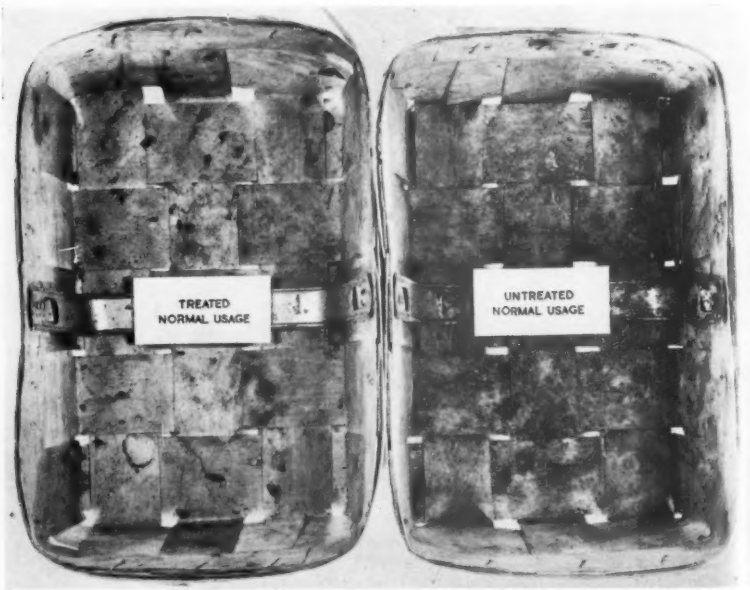


Photo: Scottish Horticultural Research Insti

2. *Left:* Basket treated with copper-8-quinolinate formulation.
Right: Untreated showing growth of moulds.

PLATE II

POTATO VIRUS A IN ULSTER TORCH (see pp. 144–6)

Photo: Ministry of Agriculture, Northern Ireland

1. Terminal foliage (*left*) virus free, (*right*) showing moderately severe symptoms.

DETECTION OF LEAF ROLL IN POTATO TUBERS (see pp. 126–8)

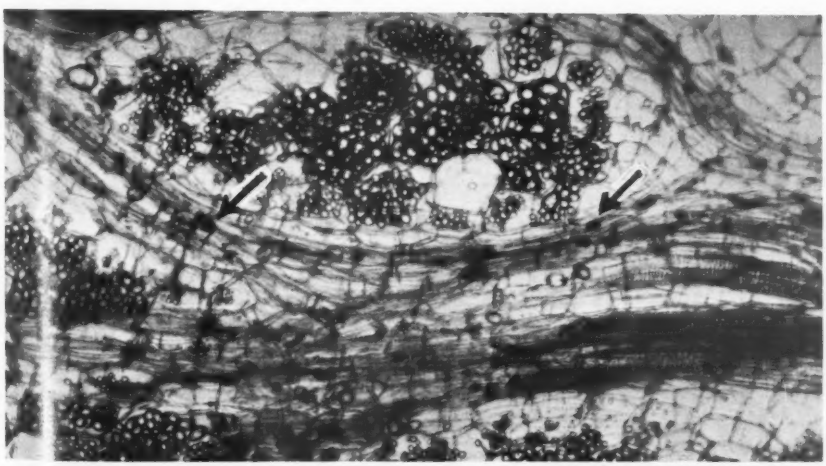
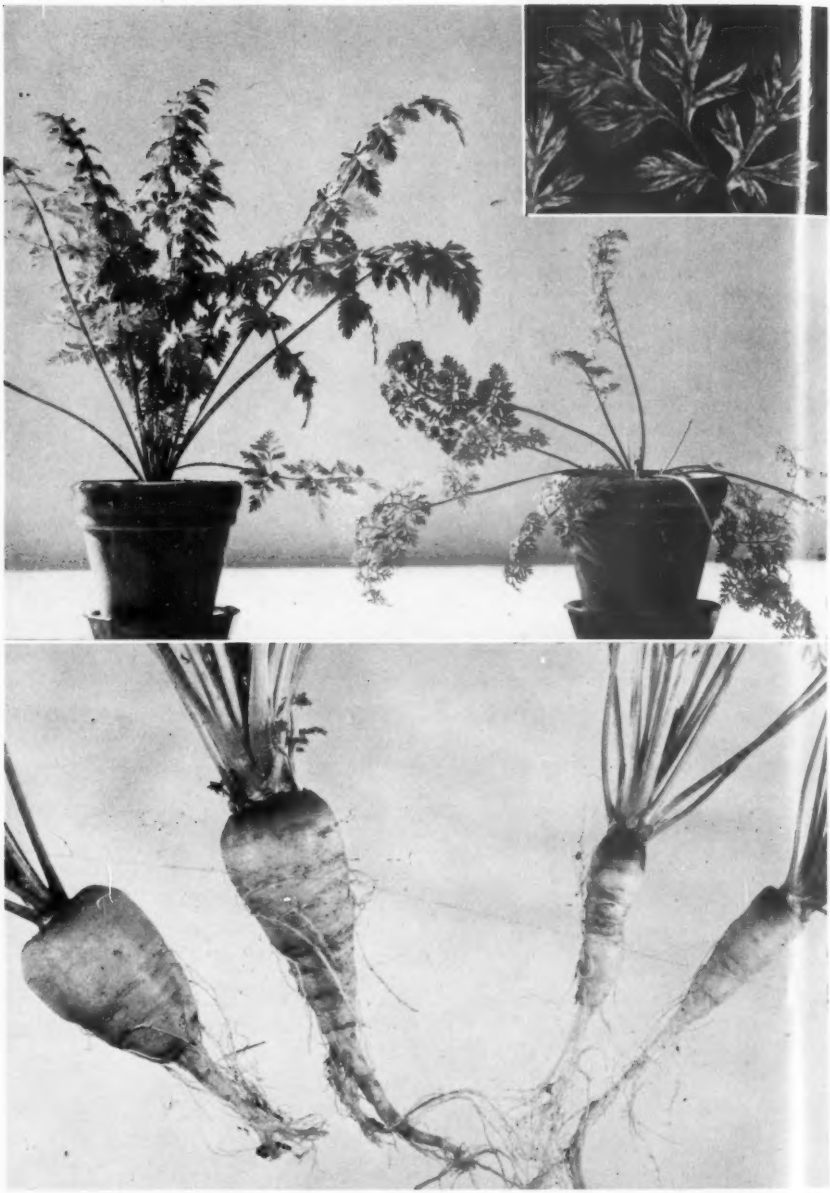


Photo: Rothamsted Experimental Station

2. Section of vascular tissue showing callose plugs in sieve tubes. (× 80)

PLATE III

CARROT MOTLEY DWARF VIRUS



Photos: Rothamsted Experimental S tion

Plants grown in the glasshouse during winter, and photographed on April 7, 1960, three m ths after the plant on the right had been inoculated with motley dwarf virus. Healthy plant on eft. (*Below*): Roots from healthy and infected plants. (*Inset*): Leaflet showing characteristic mott .

PLATE IV

SPRAYING TRIALS AGAINST BLACK CURRANT GALL MITE

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INEFFECTIVE control of black currant gall mite with routine lime sulphur applications has been reported over a wide area during the past few years. In 1956 preliminary trials at three N.A.A.S. centres showed that endrin could give a good control of the mite. This experience provided the incentive for further work with endrin and other materials on a co-operative basis. The present paper is an account of observations and spraying trials carried out within the N.A.A.S. over the years 1957–59. The work complements and extends the chemical screening trials already reported by Collingwood and Dicker (1960).

In 1957, double applications of endrin gave good control in three trials but poor results were obtained in two others. It was thought that these differences in response might have been due to the varying amounts of wash used, variation in plot layout, application times and assessment methods. All these were therefore standardised for subsequent work in 1958 and 1959.

METHODS

The main trials were carried out on mature substantially infested bushes of either Baldwin or Wellington XXX on commercial plantations. In 1958 plot size was fixed at three or four rows of four bushes with four replicates. In 1959 this was modified to single rows of four bushes with five replicates, which layout had given equally good results in screening trials in the East Midlands in 1958. In addition opportunity was taken of observing the effects of spraying large unreplicated plots of an acre or more on growers' holdings. Care was taken to adjust the amounts of wash so as to soak the bushes thoroughly; on the small plot trials this worked out at approximately one gallon to every four or five bushes, or 260–320 gallons per acre.

Application times were standardised at first open blossom and at three weeks after this date, coinciding with early fruit set, since observations in 1957 as well as the screening trials (Collingwood and Dicker, 1960) had shown that these were the most effective times for pre- and post-blossom applications respectively. The dates for the first application ranged from April 22–29 in 1958 and April 10–15 in 1959. The sprays were applied by low pressure side-pump knapsacks or by hand lance from power sprayers on the small plots, and by automatic power sprayers on the larger plots. The treatment effects were assessed by estimating the numbers of galled buds per cent on ten and twenty shoots taken from the centre bushes in each plot before treatment, and in the autumn following treatment, respectively.

MATERIALS

Chemicals in common use against Tetranychid mites were not found to be generally effective against gall mite in the screening trials (Collingwood and Dicker, 1960). On the other hand chemicals known to be active against certain Tarsonemid mites include some that have been found useful for gall mite control, and particular attention has been given in the present work to materials that have been reported to be effective against cyclamen mite, *Steneotarsonemus*

pallidus Banks. Allen, Nakakihara, and Schaefers (1957) reported on tests with 50 compounds against this pest on strawberries. They found that endrin, azobenzene and Thiodan gave a very good control, and chlorobenzilate and Kelthane a partial control. In addition, fluoroacetamide has been found to control cyclamen mite on ornamentals in Britain by Vernon and Collingwood (unpublished work).

In the present trials, Kelthane was tried extensively in 1957 but found to be useless; this material, and also chlorobenzilate, were ineffective in the screening trials (Collingwood and Dicker, 1960). Azobenzene at 0·05 per cent was tried in the Eastern Region in 1959 but had no effect (Table 2). The main trials in 1958 compared lime sulphur at 2 per cent as the standard material with endrin, and in 1959 also with fluoroacetamide and Thiodan.

Endrin was used throughout at 0·04 per cent of the standard commercial emulsifiable concentration, as a preliminary trial in the West Midlands in 1956 had established that there was a significant improvement in control with 0·05 per cent as compared with 0·025 per cent, while the screening trials (Collingwood and Dicker, 1960) had shown no increase in effectiveness at strengths higher than 0·04 per cent. Thiodan and fluoroacetamide were both used at 0·05 per cent (except where otherwise stated in Table 2) of the standard commercial formulations available in 1959. Dioctyl sodium sulphosuccinate at 0·02 per cent was added to every spray but not to lime sulphur except in the South Western Region.

TABLE 1

Main Spray Trial Results, 1958

Centre	Treatment	Dates of spraying	Galled buds *Mean per cent*			Angular Transformation	Sig. Diff. (P = 0·01)
			Pre-treat.	Post Harvest	Mean Reduction		
South Western Region 1	Lime sulphur ..	April 23	71	36	38	38	
	Endrin	April 23, May 14	71	3	94	76	
	Endrin	April 23, May 14, July 21	73	3	94	77	
	Control ..		66	53	0	0	6
South Western Region 2	Endrin	April 29, May 20	66	1	98	83	
	Endrin	May 20, June 6	73	9	86	68	
	Endrin	April 29, May 20, May 6	72	1	99	86	
	Control ..		76	68	0	0	7
	Endrin	April 29, May 20	15	1	93	75	
	Endrin	May 20	52	9	79	64	
	Endrin	May 20, May 6	18	4	66	56	
	Control ..		76	68	0	0	19
Eastern Region 1	Lime sulphur ..	April 22, May 19	11	9	18	17	
	Endrin	April 22, May 19	24	2	93	7	
	Control ..		7	17	−143	24	12
East Midland 1	Lime sulphur ..	April 29	18	6	44	14	
	Lime sulphur ..	April 29, May 19	17	4	51	12	
	Endrin	April 29	17	1	61	4	
	Endrin	April 29, May 20	19	1	64	4	
	Control ..		16	12	0	20	4

Results from the main trials in the East Midlands, Eastern Region and South Western Region are shown in Tables 1 and 2. All figures are given to the nearest whole number. Where final counts on untreated plots were lower than the original pre-treatment counts, the estimated per cent infestation reduction has been subjected to Abbott's correction. It will be noted that in 1958, the infestation on control plots was static or tended to decline at three sites; in 1959 all the controls increased sharply by about 100 per cent. Significant differences relate to the angle transformations in the adjacent column. In the South Western Region all analyses were made on the percentage infestation reduction per plot; in the other trials analyses were based on the final post treatment plot counts.

TABLE 2

Main Spray Trial Results, 1959

Centre	Treatment	Dates of spraying	Galled buds *Mean per cent*			Angular Transformation	Sig. Diff. (P = 0·01)
			Pre-treat.	Post Harvest	Mean Reduction		
South Western Region 3	Lime sulphur ..	April 3, May 5	28	25	2	9	
	Endrin	April 15, May 5	27	4	85	68	
	Fluoroacetamide	April 20, May 5	29	7	75	60	
	Thiodan ..	April 20, May 5	39	18	48	44	
	Control ..		38	62	− 65	−55	24
Eastern Region 2	Endrin	April 13, May 4	16	9	44	16	
	Thiodan ..	April 13, May 4	18	16	15	24	
	Azobenzene ..	April 13, May 4	20	43	−115	41	
	Control ..		25	48	− 90	43	17
East Midland 2	Lime sulphur ..	April 13	19	26	− 37	31	
	Lime sulphur ..	May 6	19	30	− 58	33	
	Endrin	April 13	19	12	36	20	
	Endrin	May 6	19	3	83	10	
	Endrin	April 13, May 6	21	1	95	4	
	Fluoroacetamide						
	0·05 per cent	April 13	19	37	− 95	38	
	0·025 per cent	May 6	19	14	26	22	
	0·05 per cent	May 6	19	9	52	17	
	0·1 per cent	May 6	19	6	68	10	
	0·05 per cent	April 13, May 6	20	3	85	10	
	Thiodan ..	April 13	19	34	− 78	36	
	Thiodan ..	May 6	19	14	26	22	
	Thiodan ..	April 13, May 6	17	11	32	20	
	Control ..		18	46	−175	43	10
East Midland 3	Thiodan ..	April 17		8		17	
	Thiodan ..	April 28		6		14	
	Thiodan ..	May 11		3		9	
	Control ..			30		35	
	Thiodan						
	0·025 per cent	April 13		16		24	
	0·1 per cent. ..	April 13		5		13	15

Additional information from less detailed trials carried out in the East Midlands, South Eastern Region and the West Midlands has been used to compare the general effectiveness of the four main chemicals over a wide variety of sites with results shown in Table 3.

TABLE 3

Comparison of Miticidal Efficiency
(Data from all Trials 1958–59)

Applications	Lime sulphur		Endrin		Fluoroacetamide		Thiodan	
	No. of Trials	Mean Reduction *per cent*	No. of Trials	Mean Reduction *per cent*	No. of Trials	Mean Reduction *per cent*	No. of Trials	Mean Reduction *per cent*
One pre-blossom	7	9	8	16	2	−62	3	−28
One post blossom	2	−20	4	84	5	69	4	53
One pre- and one post blossom	4	23	13	89	3	81	6	34
All trials ..	13	5	25	65	10	43	13	25

Lime Sulphur. This chemical was fully investigated in the screening trials (Collingwood and Dicker, 1960), where it was found to be consistently inferior to endrin at all strengths and combinations of application times used. Results from the present series of trials confirm that although a slight reduction of original infestation may sometimes be obtained especially where lime sulphur is applied both before and after blossom, the effects are not consistent or reliable. In Norway, Taksdal (1959) found that the final infestation was the same as on the control plots even after a programme of one pre-blossom and two post blossom sprays applied to the same plots over a two year period.

Endrin. The screening trials (Collingwood and Dicker, 1960) showed that very good control could be established with this chemical with only one post blossom application, but there was a suggestion from two of the trials that slightly improved results were obtained with two sprays. In the present series of trials consistently good results were obtained by a programme of two sprays but a single suitably timed post blossom spray was only slightly less effective.

Taksdal (1959) obtained similar results in Norway with one pre-blossom plus one post blossom application and also showed that an additional pre-blossom spray did not result in significantly improved control while sprays applied in the late summer after harvest were useless. In the screening trials (Collingwood and Dicker, 1960) there was a marked falling off in the degree of control with single sprays applied two or three weeks after full fruit set. Similarly an additional spray in the South Western Region two weeks after fruit set in 1958 gave no improved control, while post harvest sprays in three other trials gave no control, and it is evident that by the time fresh galls become visible the mites are completely protected by the overgrowth of bud tissue from the effects of endrin.

It was shown (Collingwood and Dicker, 1960) that endrin was capable of destroying mites within the new axillary buds up to and during the fruit setting period as well as preventing mite invasion and that, as a consequence, actual numbers of mites in infested buds were fewer on endrin sprayed than on untreated shoots. Similar observations were made in the Eastern Region in

both 1958 and 1959 (Table 4), while in the South Western Region mite counts confirmed that this relative difference in numbers persisted into late autumn (Table 5).

TABLE 4

Early Assessment of Infestation: Eastern Region

	June			November
	No. buds	Infested *per cent*	Total mites	Buds infested *per cent*
1958				
Endrin	219	1	5	2
Lime sulphur	203	6	26	9
Control	216	18	229	17
1959				
Endrin	91	13	15	11
Thiodan	81	12	26	15
Azobenzene	85	54	401	46
Control	87	61	703	55

TABLE 5

Mite Counts in November: South Western Region, 1957

Treatment	No. buds examined	Galled *per cent*	Mean No. mites per bud		
			Galled	Normal	All buds
Endrin	1,229	14	3,315	17	464
Kelthane	1,158	87	4,692	93	4,103
Control	1,057	79	4,033	96	3,340

In the Eastern Region mite counts were made by examining dissected buds under a binocular microscope. Results in both 1958 and 1959 show a very close correspondence between the estimates of per cent infestation in June from a relatively small number of buds and those obtained from the same plots in November by the standard method of gall counts adopted throughout the trials. It seems that this early examination could provide a reasonably quick and reliable method of assessing the performance of various insecticides and the results also confirm the observations of Collingwood and Brock (1959) that very little, if any, mite invasion of fresh buds occurs normally after early June.

In the South Western Region, mite estimates were made by counting 1 cc. suspensions after breaking up the buds and stirring in a mixer using a similar technique to that described by Collingwood and Brock (1959). The mite counts obtained confirm the general reliability of the method of assessment of infestation by gall counts although a certain proportion of infested buds escaped detection on all plot samples through their apparently normal appearance.

Fluoroacetamide. Collingwood and Dicker (1960) found that this chemical showed only mild promise with a single application at 0·02 per cent but was nearly as effective as endrin when applied twice after blossom at 0·1 per cent.

In 1959 fluoroacetamide was compared in the East Midlands using 0·025, 0·05 and 0·1 per cent in single post blossom applications. The degree of control increased with the concentration used, and there was an indication from three of the trials that results with single applications of 0·05 per cent after blossom were almost as good as with similar endrin sprays. The combination of one pre-blossom and one post blossom application gave rather better results than a single post blossom application as was found with endrin, but applications before blossom alone had very little effect. No phytotoxic effects were noticed with this chemical in the East Midlands in either 1958 or 1959, or on a grower's holding where an acre block was sprayed, but there was some loss of fruit after the post blossom application in the South Western Region.

Collingwood (1958) reported on the use of fluoroacetamide for the dis-infestation of cuttings taken for propagation. It was found during a series of dipping tests using the insecticide at various strengths that mites within mature galls could be killed by immersing infested shoots for ten minutes. Complete mortality of the mites occurred with 0·5 per cent solutions but at this strength there was some phytocidal effect resulting in partial failure to root. At 0·1 per cent partial but not complete mortality was obtained while at 0·2 per cent mortality was in the neighbourhood of 98 per cent as far as could be judged by opening galled buds a week after treatment and examining the mites under a microscope. At these strengths phytotoxic effects were negligible and infested cuttings have been rooted and grown on normally following treatment in the dormant period in trials in the East Midlands. The effect on the mites was an apparent paralysis but mortality could only be judged by total absence of movement since no internal break-down appeared until after a lapse of several weeks. Mortality of mite eggs was of a lower order than for the active mite stages and some hatch occurred when the proportion of eggs in the galls was high. For this reason, Collingwood (1958) suggested that the best time for cutting treatment would be in the dormant period from mid October to early January when eggs are present only in relatively low numbers (Collingwood and Brock, 1959).

Fluoroacetamide was shown to have systemic properties by David and Gardner (1958) when used as an aphicide. The effectiveness of this insecticide in relation to mite control seems to result from local penetration of surface tissues and not from a systemic effect. No results were obtained by watering bushes at various strengths before blossom or after harvest and only small numbers of mites within the outer scales of some galls were killed when bushes were sprayed in July 1957 in the East Midlands, while post harvest sprays in the South Western Region 1959 gave no control. It is also probable that gall mites are not susceptible to the present range of systemic insecticides since watering or spraying with strong concentrations of dimefox, mazidox, schradan or Tetram as well as other chemicals in the Eastern Region in early August, 1958, had no discernible effect. In the screening trials it was shown that the particular value of endrin against gall mite lay in its property of destroying those that had already entered newly forming buds while the latter were still in an early stage of development. Fluoroacetamide evidently has this property to an even greater degree than endrin, but when applied before blossom appears to lack the protective persistence of the latter.

Thiodan. This insecticide appeared to be only slightly inferior to endrin when applied twice after blossom in 1958 in one of the screening trials. Further testing in the present series of trials indicated that thiodan was somewhat less useful than either endrin or fluoroacetamide. When applied after blossom with or without an earlier spray only a slight reduction of the original infestation

was obtained. It was consistently superior to lime sulphur as a post blossom spray but its value as a pre-blossom spray, like that of fluoroacetamide, appears doubtful on present evidence.

EFFECTS ON OTHER ARTHROPODS

The effects of endrin on hive bees were considered by Collingwood and Brock (1958) who found that colonies were not harmed by the spray. These observations were repeated in the East Midlands in 1958 when three hives, kindly supplied by Mr. B. A. Cooper, were placed along black currant rows and deliberately sprayed with 0·5 per cent endrin on 20th May. A few bees were killed but no adverse effects on the subsequent development of the colonies could be observed.

Collingwood and Brock (1958) showed that with suitable timing endrin gave good control of capsids, aphids and leaf curl midge. Additional pests found to be adequately controlled by this insecticide included *Eulecanium corni* Bouché at one site in the East Midlands and *Typhlocyba rosae* (L.) in the South West Region. In the East Midlands (Table 6) a visual scoring method showed that endrin gave somewhat better control of capsid and midge than thiodan, and both materials were superior to fluoroacetamide against these pests.

TABLE 6

Midge and Capsid Control: East Midlands, 1959
(*Untreated control = 100*)

	Applied pre-blossom		Post blossom		Pre and post blossom	
	Midge	Capsid	Midge	Capsid	Midge	Capsid
Thiodan 0·05 per cent	45	95	19	25	19	23
Fluoroacetamide 0·05 per cent ..	100	100	83	88	84	87
Endrin 0·04 per cent	37	18	12	20	2	5

An infestation of glasshouse red spider mite, *Tetranychus telarius* L., developed in 1957 in the South West Region. Three of the four endrin treated plots developed a conspicuously heavier infestation than on control plots, presumably through destruction of predators, whereas populations were significantly reduced on kelthane treated plots (Table 7).

TABLE 7

Effect of Sprays on Glasshouse Red Spider Mite: South Western Region, 1957
(*Counts on 80 Leaves per Treatment in July*)

Treatment	Date of Spraying	Red Spider Mite		Mean log Trans-formation
		Total No.	Mean Plot	
Endrin 0·05 per cent ..	April 2, May 1	5,650	1,415	3·12
Endrin	May 1, May 21	5,700	1,450	3·12
Endrin	May 21	4,255	1,064	3·02
Control		3,220	805	2·87
Kelthane 0·04 per cent ..	April 2, May 1	1,280	320	2·40
Kelthane	May 1, May 21	739	185	2·23
Kelthane	May 21	2,090	525	2·24
Significant Difference (p = 0·05)				0·53

DISCUSSION

The use of endrin and lime sulphur have already been fully considered by Collingwood and Dicker (1960). From the experience now available with lime sulphur, it is clear that no worthwhile reductions of heavy gall mite infestations can be expected with any form of application. At best sulphur delays the rapidity of infestation build-up. At the same time the use of endrin which is only fully effective when applied immediately after blossom, is restricted on fruiting bushes by official recommendation to the pre-blossom period only. With this limitation, build-up of infestation may be prevented, but reduction of heavy infestations is unlikely.

The newer materials, fluoroacetamide and Thiodan, are on present evidence only effective when applied after blossom. Fluoroacetamide is of relatively high mammalian toxicity and, while its persistence may be less than that of endrin, uncertainty as to its behaviour within the plant after application has delayed any final decision on residue tolerance and use on soft fruit after blossom. Thiodan residues on harvested fruit from plots sprayed experimentally after blossom have been found to be of the same order as those obtained with endrin, according to information kindly supplied by Dr. H. Egan of the Government Chemical Laboratory. Moreover this chemical has appeared rather less effective biologically against gall mite than fluoroacetamide and may require higher dosage rates or more applications to achieve comparable results.

The present situation therefore may be summed up by suggesting that the use of fluoroacetamide dip treatments where appropriate on cutting material, followed by thorough endrin spraying immediately before and after blossom, should ensure freedom from gall mite up to the first year of fruiting. Endrin is the preferred material for non-fruiting plantations owing to its greater general efficacy against other common pests. Thereafter the annual use of endrin before blossom, or of fluoroacetamide post blossom if permissible, or of two or more sprays of lime sulphur, would protect the plantation from developing any appreciable infestation. Meanwhile the problem remains of obtaining adequate chemical control in infested but still profitable plantations.

One suggestion could be to destroy the fruit for one season so as to admit the free use of endrin or other effective materials after blossom on the heavily infested areas. Ancillary physical measures, such as cutting bushes to the ground or picking off galled buds, are not considered to have any practical value (Collingwood, 1958). Heavy pruning out of old wood however is desirable to facilitate adequate spray cover. Poor control with endrin when used experimentally on growers' holdings in 1957 was referred to in the screening paper and attributed to poor spray cover.

Results on large plots in 1958 and 1959 in the present series of trials, using the normal spray equipment and methods of the growers concerned, gave results that compared well with those from small plots and it would appear that there is no special difficulty in obtaining good chemical control on a field scale provided attention is given to thorough wetting of the leaf axils. High volume sprays appear to be necessary for good results but no comparisons have been made in the course of the present work other than those reported in the screening paper where low volume applications of concentrate lime sulphur gave inferior results to high volume sprays of 2 and 4 per cent in two trials in Kent. At the same time, work with fluorescent tracers by Staniland (1960) has shown that conventional high volume sprays give more reliable cover than low volume mist or air blast sprays on black currants.

SUMMARY

Information from co-operative spraying trials against black currant gall mite over a wide variety of sites during the years 1956 to 1959 has been collected together. The four chemicals found to be effective by Collingwood and Dicker (1960) have been given further extensive tests. Their performance has been assessed by comparing gall counts in the autumn following treatment with those on the same plots before treatment and estimating the overall mean reduction of infestation. The chemicals in order of comparative effectiveness are endrin, fluoroacetamide, Thiodan and lime sulphur, which gave overall mean reductions of 65, 43, 25 and 5 per cent respectively.

Endrin has been shown to have no deleterious effects on colonies of hive bees which were deliberately exposed to sprays. It is considered to be the most useful material for nursery beds and non-fruiting plantations, both for control of gall mite and of other pests with the exception of red spider mite, and has given better results when restricted to pre-blossom applications than any of the other materials.

Fluoroacetamide compared closely with endrin when applied at 0·05 or 0·1 per cent after blossom but was ineffective when applied before blossom. This insecticide was found to destroy mites within mature galls when infested shoots were dipped for 10 minutes in solutions of 0·1 per cent or more, but had no apparent systemic effect when applied by watering or spraying mature bushes before blossom or after harvest. Slight fruit loss was observed in one out of five spraying trials.

Thiodan gave inferior results to fluoroacetamide when compared as a post blossom spray at 0·05 per cent but was more effective than lime sulphur when used at that time.

Grateful acknowledgment is made to Miss A. M. Brock, Mr. K. J. Coghill, Mr. C. W. Graham and Mr. B. D. Moreton all of whom contributed to the results reported; to members of respective Entomology Departments who assisted with the work; and finally to the many growers and institutes on whose holdings the trials were conducted.

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POTATO VIRUS A IN THE VARIETY ULSTER TORCH

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POTATO virus A, which occurs very infrequently in Northern Ireland seed potatoes, was found to be the main cause of mosaic symptoms noted in the variety Ulster Torch in several districts in the years 1957 and 1958. (*Res. Exp. Rec. Min. Agric. N.I.*, 1958, **7**, 226 and 1960, **8**, 179). The same virus, alone or in combination with virus X, was detected in a number of crops of this variety in Scotland. (Todd, *in lit.*, 1958). Infection with virus A was diagnosed mainly by sap inoculations to *Nicotiana tabacum* L. var. White Burley and to *Solanum demissum* L. strain P.I.175404 which reacts with black necrotic local lesions (Webb and Buck, 1955) while other viruses were detected by using additional indicator plants and by serological tests.

The symptoms produced by virus A in Ulster Torch ranged from a mild blotchy mottle to a severe chlorotic mottle accompanied by distortion, reduction in leaflet size and a tendency to reddish brown pigmentation and necrosis at the margins. It was often possible to find a wide variation in symptoms within a single crop. Current year infection was observed in a number of crops in 1957; the symptoms were as described but occurred in only a proportion of the stems of affected plants. The presence of virus A was confirmed in mottled leaves but not in symptomless leaves. No work has been carried out on insect transmission and a survey of aphid spp. in affected crops has not been made.

MacLachlan, Larson and Walker (1953) and Rozendaal (1954) have differentiated between distinct strains of virus A but in Ireland only a mild type had previously been recognised (Clinch, Loughnane and McKay, 1944). To investigate the possible occurrence of strains of virus A in Ulster Torch and the reaction of other potato varieties to infection a core grafting experiment was carried out in 1959.

TRANSMISSION BY CORE GRAFTING

Materials and Method. The tubers from a number of single affected plants of Ulster Torch selected in the field in 1957 were planted at the Plant Pathology Field Station in 1958. Three clones tested and found to be free from viruses X, Y and S but showing severe, moderately severe (Plate III, 1) and mild mosaic symptoms, respectively, were chosen to provide material infected with virus A for core grafting. Cultures of virus A which had been maintained in the varieties Irish Chieftain and Golden Wonder for some years were used for comparison. The tubers to be grafted were procured from virus tested clones of Ulster Torch, Arran Banner and Arran Victory, respectively, Arran Banner and Arran Victory being selected because they are the most widely grown varieties in Northern Ireland which are tolerant to virus A. A lesser number of tubers of the varieties President, Majestic, Up-to-Date and U.S. Seedling 41956, virus free or of known virus infection and selected from stocks maintained under glass at the Field Station, were also grafted with some of the cultures.

Grafting was carried out during the last week of February when sprouts were beginning to develop, using the method employed by Murphy and McKay (1926). The grafted tubers produced strong sprouts under cool, well-lighted

storage conditions and were planted in the field on May 15. Ungrafted tubers of each variety in addition to tubers of the three clones of Ulster Torch infected with virus A were planted in the field for comparison while the cores taken from the grafted tubers, each bearing an eye, were planted in 3-inch pots in the glasshouse. Visual observations on the growing plants were made from time to time and, in cases of doubt, infection with virus A or virus X was confirmed by sap inoculation tests and serological tests respectively.

Results. Out of a total of 100 grafted tubers of tolerant varieties only one Arran Banner tuber failed to produce an infected plant while three of four plants raised from grafted tubers of the field immune variety, Up-to-Date, developed top necrosis. Varietal reaction to infection varied but the classification of the cultures according to the severity of the symptoms produced was the same for each tolerant variety. The most marked differences in symptom expression occurred in Ulster Torch and President while in U.S. Seedling 41956 the differences were least obvious. In Arran Banner and Arran Victory the symptoms ranged from a definite mottle with reduction in leaflet size to a barely perceptible mottle, the presence of the virus in the latter plants having to be confirmed by sap inoculation tests. Some of the grafted Majestic tubers used were known to be infected with virus X but differences in symptoms due to the culture of virus A used were obvious irrespective of whether viruses X and A or only virus A were present. The culture of virus A from Golden Wonder and the mild culture from Ulster Torch consistently produced identically mild symptoms in the varieties under test while that from Irish Chieftain caused more definite symptoms although less severe than those brought about by the more virulent cultures from Ulster Torch. The results obtained would indicate, therefore, that the cultures used consisted of the four following strains: (1) severe (ex Ulster Torch), (2) moderately severe (ex Ulster Torch), (3) mild (ex Irish Chieftain) and (4) very mild (ex Ulster Torch and Golden Wonder).

The severely affected plants matured prematurely and, while their numbers did not permit the carrying out of yield tests, it was apparent at lifting time that yields were reduced.

DISCUSSION

Virus A has normally been associated with mild mosaic symptoms, its significance being in the development of crinkle when combined with virus X. Routine leaf testing in recent years has indicated the rare occurrence of virus A in seed growing areas of Northern Ireland and this finding is supported by the virtual absence of crinkle in stocks of varieties tolerant to virus A and known to be partially affected with mild strains of virus X. It has been difficult, therefore, to account for the relatively high contamination with virus A occurring in occasional crops of Ulster Torch in different districts and for the incidence of the different strains of this virus. The transmission of selected cultures of virus A by tuber core grafting has confirmed that the symptom variations, noted in Ulster Torch in the field, will also occur in other tolerant varieties although not always to the same extent. The source of the virulent strains affecting Ulster Torch cannot be traced to the natural occurrence of similar strains in other varieties and it is suggested that they may have arisen in plants of this variety following an initial infection with a mild strain. This view is supported by the occurrence of mild and severe symptoms in plants of the same stock. It is not known when Ulster Torch, which was introduced in 1953, first became infected, but it is probable that infection took place in the early stages of propagation. This would account for the widespread contamination and also for the relatively high percentage of infection in Ulster Torch as compared with other varieties in seed growing districts.

SUMMARY

Potato virus A was found to be the main cause of mosaic symptoms observed in crops of the variety Ulster Torch in Northern Ireland. Four strains of virus A were differentiated when cultures from Ulster Torch, Irish Chieftain and Golden Wonder were transmitted by core grafting to a number of tolerant potato varieties. It is suggested that the virulent strains occurring in Ulster Torch may have arisen in this variety after an initial infection with a mild strain.

I am indebted to Professor A. E. Muskett for his helpful criticism of this work, to the personnel of the Potato Inspectorate Division, Ministry of Agriculture for Northern Ireland, with whom visits to farms were made and to Mr. R. McIlwaine for the photographs.

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THE RE-TREATMENT OF SOILS WITH DIELDRIN FOR THE CONTROL OF CARROT FLY

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EXPERIMENTS in progress for the past five years, both at Wellesbourne and in the Fenlands of Cambridgeshire, have shown that an excellent control of carrot fly *Psila rosae* can be obtained by mixing aldrin, dieldrin or heptachlor into the top 4 inches of soil before sowing carrots (Wright, 1958, 1959, 1960). In general, dieldrin is the most satisfactory of these insecticides and it is now being widely used at doses of 0·75 and 1·5 lb per acre in mineral and highly organic fen soils respectively. These experiments have also demonstrated that a single application of dieldrin remains active against carrot fly, although to a decreasing extent, for a number of years, and bioassay of soil samples has confirmed the extreme persistence of residues of dieldrin.

In some areas, carrots are grown in very short rotations and re-treatment of the soil may occur within 2 or 3 years of a previous application. If the amounts of dieldrin indicated above are applied too frequently, there is a danger that residues may accumulate to undesirable levels in the soil. However, it should be possible to prevent this occurring if smaller amounts are applied when re-treating soil.

RATE OF LOSS OF DIELDRIN

Evidence from the U.S.A. (Lichtenstein and Schultz, 1959) suggests that insecticide residues decay approximately exponentially when considered over a number of years and thus the half-life can be used as an approximate measure of persistence. The half-life of dieldrin in a mineral soil at Wellesbourne has been shown to be about 4 years (Wheatley and Hardman, 1960). Bioassay of residues in fen soil treated with 2 and 4 lb of dieldrin per acre in 1956 has shown that 1·4 and 2·5 lb per acre respectively still remained in January, 1960. Thus, in fen soil persistence was apparently greater than in mineral soil and the half-life can be estimated to be about 5–7 years.

ACCUMULATION OF RESIDUES

The extent to which residues accumulate in the soil will depend on the amount of insecticide applied, its rate of loss and the frequency of the applications. It can be shown that, for any given combination of constant values for these factors, the residues should eventually converge in the *n*th rotation towards a maximum level (R_{max}) given by $R_{max} = d/p$ where d is the applied dose and p is the proportion lost in the interval between applications; R_{max} is approached closely after about the third cycle of events. For instance, if the half-life equals the interval between applications, $p = 0{\cdot}5$ and $R_{max} = 2d$. Assuming a half-life of 4 years, maxima have been calculated for dieldrin and are shown in Table 1. Since the half-life of dieldrin in soil is probably longer than 4 years, the maximum residues may tend to exceed the amounts indicated. Thus, re-treating fen soil with 1·5 lb dieldrin per acre every 3 years would probably lead to residues of about 4 lb per acre in 12 years and tasting tests at Wellesbourne have shown that such levels of dieldrin may cause a loss of flavour in carrots in certain seasons. Furthermore, carrots appear to absorb certain insecticides from the soil and undesirable amounts may occur in the roots which have been grown in soil containing high residues of dieldrin.

TABLE 1

Maximum Residues (lb per acre) for Dieldrin Assuming a Half-life of 4 Years

Dose applied lb/acre	Interval between applications, years					
	1	2	3	4	5	6
0·5	3·1	1·7	1·2	1·0	0·86	0·77
0·75	4·6	2·2	1·8	1·5	1·3	1·2
1·0	6·2	3·4	2·4	2·0	1·7	1·5
1·5	9·3	5·2	3·7	3·0	2·6	2·3
2·0	12·0	6·9	4·9	4·0	3·4	3·1

RE-TREATMENT OF SOIL

The persistence of insecticidally active residues for several years suggests that, when re-treating soil, it should be necessary to make good only the insecticide lost in order to regain the original desired potency of the treatment. Immediately following the initial application, the insecticide will be contained solely within the top 4 inches of soil. Subsequent ploughing will dilute the concentration of insecticide in the soil by a factor which will be the number

of times the plough depth exceeds 4 inches (Wheatley and Hardman, 1960). Little is known about the relative efficiencies of insecticide occurring above and below the 4 inch depth for carrot fly control, so that, at present, the aim when re-treating the soil should be to restore the concentration of insecticide in the upper 4 inches to its original value. The amounts of dieldrin required to do this have been calculated (Table 2) assuming a half-life of 4 years and a ploughing depth of 8 inches.

TABLE 2

Amounts of Dieldrin (lb per acre) Required to Restore the Concentration in the Top 4 Inches of Soil

Initial dose lb/acre	Interval between applications, years					
	1	2	3	4	5	6
0·5	0·3	0·3	0·4	0·4	0·4	0·4
0·75	0·4	0·5	0·5	0·6	0·6	0·6
1·0	0·6	0·6	0·7	0·8	0·8	0·8
1·5	0·9	1·0	1·0	1·1	1·2	1·2
2·0	1·2	1·3	1·4	1·5	1·6	1·6

The rates of loss of dieldrin from soils are being further studied so that the amounts necessary for re-treating soils can be determined more precisely but it will take some years to obtain this information. Meanwhile, because available evidence suggests that the half-life of dieldrin mixed with soil is not less than 4 years in the United Kingdom, it would seem to be inadvisable to exceed the amounts given in Table 2 when re-treating soils with this insecticide.

SUMMARY

The half-life of dieldrin in soil appears to be not less than 4 years in the United Kingdom and therefore it seems probable that residues will accumulate to undesirable levels if soil is re-treated too frequently at the rates at present recommended. Reduced amounts for use when re-treating soils have been tabulated.

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GROWTH STIMULATION OF CABBAGE BY DIELDRIN

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FOLLOWING reports from growers that dipping the roots of cabbage transplants in dieldrin was effective in controlling club root, it was decided to compare this treatment with calomel. Roots of cabbage seedlings, variety Paragon, were washed free from soil and then dipped in one of the following: (*a*) water (control); (*b*) a paste of 4 per cent calomel dust, 1 lb in one-third pint water; (*c*) a suspension of 1 oz of pure calomel in 1 pint of an emulsion containing 0·05 per cent dieldrin (Wiggell, 1960) or (*d*) 0·05 per cent dieldrin emulsion only. All plants were given a drench of 1/8 pint each of 0·05 per cent gamma-BHC the day after planting to control cabbage root fly. Gamma-BHC was used as there has been no suggestion of any control of club root by this chemical. Each plot consisted of 4 rows of 4 plants, treatments being replicated 12 times, on a site which had carried a heavily diseased crop in the previous year. The cabbages were planted on July 8–9, and harvested on September 23, 1959, the soil being extremely dry throughout the experiment. The results were as follows:

	Mean No. of plants *per plot*	Mean weight of marketable heads *lb per plot*
Water (control)	14·5	16·3
Calomel paste (*b*)	15·0	15·8
Calomel and dieldrin (*c*) ..	15·1	18·8
Dieldrin only (*d*)	14·7	21·3
Significant difference (p = 0·05)	—	2·65

There was no significant difference in survival rate between the plants from the various treatments. One plant in a control plot showed slight clubbing, but the roots of the rest appeared to be free from clubbing and from cabbage root fly attack.

The dieldrin emulsion treatment gave a significant increase in weight of marketable heads over the untreated controls and the calomel paste treatment, while the treatment with calomel in dieldrin emulsion gave a significant increase over the calomel paste treatment and almost over the controls. The lower yield of the control plants cannot have been caused by club root nor by insect damage and the depression in the yield of the calomel paste plants is attributed to the check to growth by mercurous chloride. This also accounts for the depression in the yield from the calomel-dieldrin treatment.

Maclagan (1957) found that dieldrin used as a seed dressing at a low rate in the field stimulated the growth of parsnip seedlings. The increase in the yield from the plants whose roots were dipped in dieldrin emulsion could also be attributed to a similar growth stimulation.

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THE PRESERVATION OF FRUIT CHIP BASKETS WITH COPPER-8-QUINOLINATE

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COPPER-8-QUINOLINATE has received some attention as a crop fungicide (Martin, 1957) and has been widely used as a textile waterproofing and fungicidal agent (see, for example, Benignus, 1948). It has also been used as a timber preservative, and in this connection a solubilised formulation (Eisenschiml and Kalberg, 1948) has been used in the United States for the treatment of wooden fruit boxes, seed boxes, cold frames and comparable horticultural items (Anon., 1959). The present paper describes its use in the preservation of soft fruit chip baskets in Scotland.

One volume of a formulation containing 0·75 per cent copper-8-quinolinate and concentrated water repellents (Cunilate Wood seal) is dissolved in two volumes of industrial white spirit (100°F flash point). Baskets are dipped in the solution for 8 sec, drained and allowed to dry for at least 48 hours before use or until all trace of solvent odour has disappeared.

Treated baskets are slightly yellower in appearance than untreated baskets, but when good quality fresh white spirit is used the baskets have no odour, and no taint is imparted to fruit. The quality of white spirit is important, because one batch of white spirit (115°F flash point) which had been allowed to stand long enough for oxidation products to accumulate, imparted a strong odour to treated baskets, and a noticeable taint to fruit touching the basket. Copper-8-quinolinate itself imparts no odour or taint to fruit, and its mammalian toxicity is extremely low. For rats the L.D.50 value is 2·8 ml 10 per cent copper-8-quinolinate per kg body weight (Hilditch, 1959).

The effect on treated baskets is two-fold; firstly the baskets are water-repellent, and do not become soaked with fruit juices to any great extent, neither does fruit débris stick to the wood, and secondly, the growth and sporulation of *Botrytis cinerea*, *Rhizopus nigricans* and other fruit-rotting fungi on the wood and on débris is considerably reduced (see Plate II, 2). The overall result of the treatment is that the life of baskets used repeatedly for soft fruit is considerably prolonged. The average life of untreated four-pound baskets in continuous use for picking fruit for sale or storage in other containers is 10 days, whereas treated baskets remain relatively clean and dry for at least 10 weeks, the normal span of the soft-fruit season.

It was also found that the numbers of strawberries (var. Talisman) in four-pound batches rotting in a 24-hour period was often significantly reduced ($P < 0{\cdot}05$) from about 7 to 4 per cent by storage in treated baskets, although no such differences were observed in raspberries (var. Malling Exploit).

SUMMARY

The life of chip baskets in continuous use for picking soft fruit has been prolonged from 10 days to 10 weeks by treatment with copper-8-quinolinate. In some cases the rotting of strawberries stored in treated baskets was significantly reduced, but no such effect was observed with raspberries.

I am indebted to Mr. J. L. Warner of Cuprinol Ltd. for certain technical data.

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SUGAR BEET YELLOWS IN GREAT BRITAIN, 1959

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IN 1959 long spells of dry weather from May until November resulted in heavy and persistent infestations of both green and black aphids on sugar beet. Previous dry summers have given low yields of sugar beet due to early and widespread attacks of yellows, but in 1959 spraying helped to control aphids and yellows and the crop produced a record high sugar yield. In 146 fields sampled by the agricultural staff of the British Sugar Corporation an average of 0·5, 6·0, 14·9 and 26·2 per cent of plants had yellows at the end of June, July, August and September respectively. The percentage of the entire crop of 409,000 acres with under 1 per cent of infected plants at the end of August was 18·5; with 1–20 per cent, 41·9; with 21–60 per cent, 30·9; and with over 60 per cent, 8·7.

Yellows incidence at the end of August varied much from field to field according to the efficiency of spraying; in East Anglia, for instance, from less than 10 per cent to 100 per cent. Averages were—East Anglia 35 per cent; South 30 per cent; Lincolnshire 20 per cent; Midlands 18 per cent; West 15 per cent; Yorkshire 3 per cent and Scotland 1 per cent.

Yellows caused the following calculated losses in 1959 (cf. Hull, *Plant Pathology* 1953–1959, refs. in 1959, **8**, 145).

Calculated Percentage loss of Sugar Yield		Actual Yield per Acre Sugar	Roots*	Estimated Potential Yield of Roots per Acre	Estimated loss of Root Yield*
A†	C†	*tons*	*tons*	*tons*	*tons* (000)
6·9	10·1	2·26	14·15	15·20	429

* Converted to equivalent yields at a sugar content of 16 per cent.

† A: Assuming 4½ per cent loss for each week the plants show symptoms. C: Assuming 2·15 cwt per acre loss for each of 10 per cent infected plants at the end of August. (Calculated from yellows incidence and factory yields, 1946–57.)

High soil temperatures and long hours of sunshine favoured growth of sugar beet crops with adequate soil moisture and they gave exceptionally heavy yields—over 30 tons per acre in some fields.

On the other hand, many plants died from drought in crops on light land which missed the summer rain, and yields were very light. The country's

average yield of roots, 13·40 tons per acre has been exceeded in Great Britain only in 1958 (13·88 tons per acre); the roots had a high sugar content (16·90 per cent) and the calculated yield of sugar (2·26 tons per acre) is a record. The estimated potential yield of roots in the absence of yellows (15·2 tons per acre at 16 per cent sugar content) far exceeds the previous highest in 1950 (14·0 tons per acre).

Black aphids were numerous on sugar beet by early June and green aphids by mid-June and the infestations increased until mid-July and persisted throughout the summer. Growers were advised to spray their crops with systemic insecticide during May and June on the basis of the Sugar Corporation's daily counts of aphids on sugar beet. They responded well to the advice because they recognised the immediate threat of direct damage from black aphids and sprayed 51,000 acres in May, 253,000 in June and 77,000 in July. Of this total of 381,000 acres, 161,000 were sprayed twice and 28,000 thrice. Spraying generally controlled aphids and yellows effectively, but some insecticides gave disappointing results, especially when sprayed at low volume in hot, windy weather.

Fifteen experiments distributed throughout beet growing areas showed that a spray applied at the time the spray warning was issued increased sugar yield, on average, by 26 per cent. This large response was the combined result of preventing damage by aphids as well as loss from yellows. These results suggest that the actual root yield of 5½ million tons might well have been nearer 4 million tons had the crop not been sprayed.

NEW OR UNCOMMON PLANT DISEASES

Seed transmission of *Didymella lycopersici*. In the course of survey and investigational work at the Department of Agriculture and Fisheries for Scotland, East Craigs, Edinburgh, additional evidence has been obtained on the seed transmission of *Didymella lycopersici* Kleb. previously reported by Ogilvie (*Gdnrs' Chron.*, 1945, **118**, 71–2). Two samples of seed were extracted with water from tomato fruits naturally infected with *D. lycopersici*, sown in sterilised compost on 30th October, 1958, and grown in a heated glasshouse. The seeds were not specially selected, but the fungus was seen as pycnidia externally, and within the wall of the seed coat (Plate II, 1) of many of them. No actual count of the percentage infected was made prior to sowing. In 38 and 21 per cent of the seedlings in the two samples infection of the radicle or hypocotyl occurred, giving a type of damping-off symptom. In a further 26 and 11 per cent of the plants the infection was not apparent until they had reached from the 6–10 leaf stage. None of the control plants were infected. The delay in appearance of symptoms arising from seed-borne infection is particularly significant in connection with glasshouse practice. In a survey of 109 commercial seed samples, in which 100 seeds from each sample were incubated for 3 weeks on blotters, pycnidia of *Didymella lycopersici* were found embedded in the seed coats of a few seeds of two samples only. The samples were from the varieties Baby Lea and Kondine Red, and both had been extracted with acid.

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